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THE HARBOR OF CONSTANTZA.

By Dr. Alfred Gradenwitz.

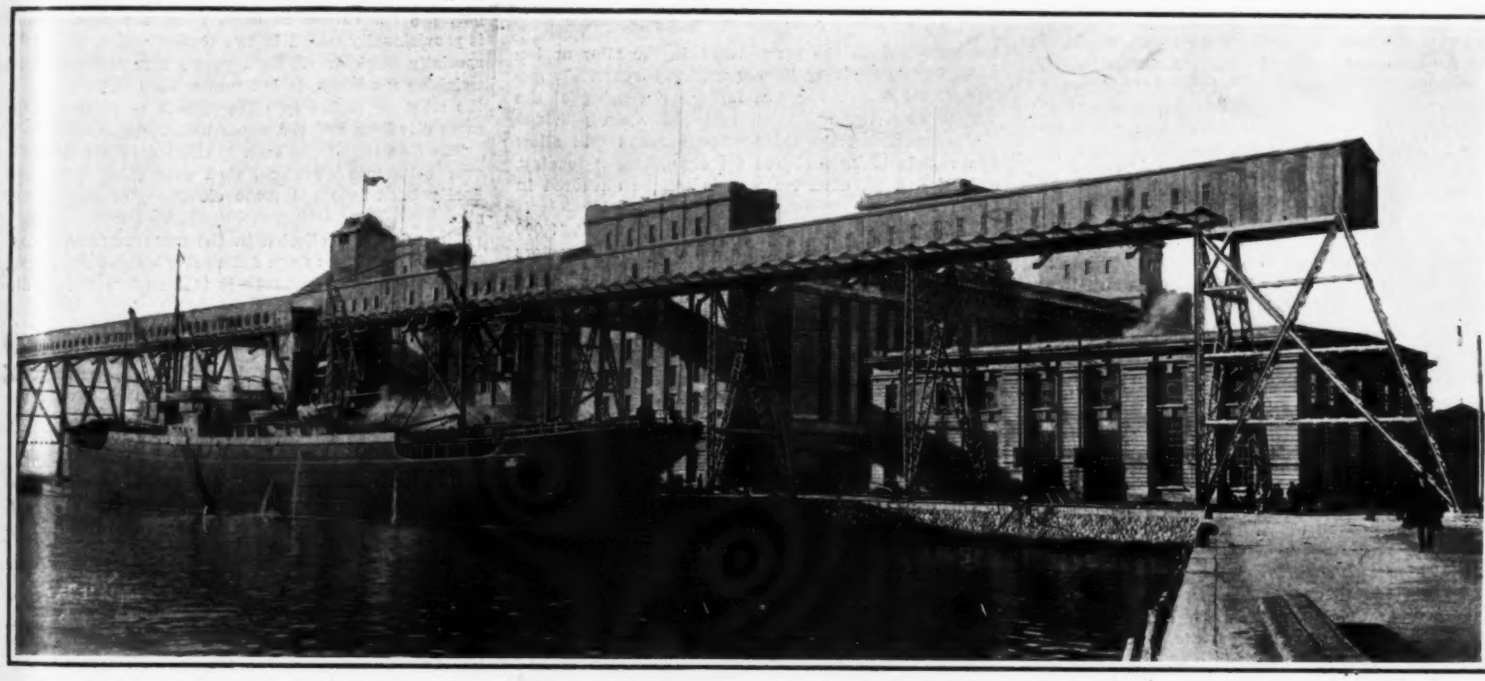
As the rather limited coast of Roumania does not comprise any natural harbor of importance, the Government, intent upon furthering commerce and trade, decided to create an artificial harbor basin at the most favorable spot in connection with the quite unimportant existing harbor works of the city of Constantza. It was commenced in October, 1896, and was recently completed.

The harbor is situated on the coast of the Black Sea in longitude 26 degrees 19′ 26″, and latitude 40 degrees 10′ 29″, and it serves for the shipment of the greater part of Roumanian export articles. Its installations, comprising granaries for 75,000,000 of kilogrammes (over 154,000,000 of pounds) of corn, are the largest on the continent. The harbor works were constructed on plans by Mr. Saligny, general director of the Roumanian state railways.

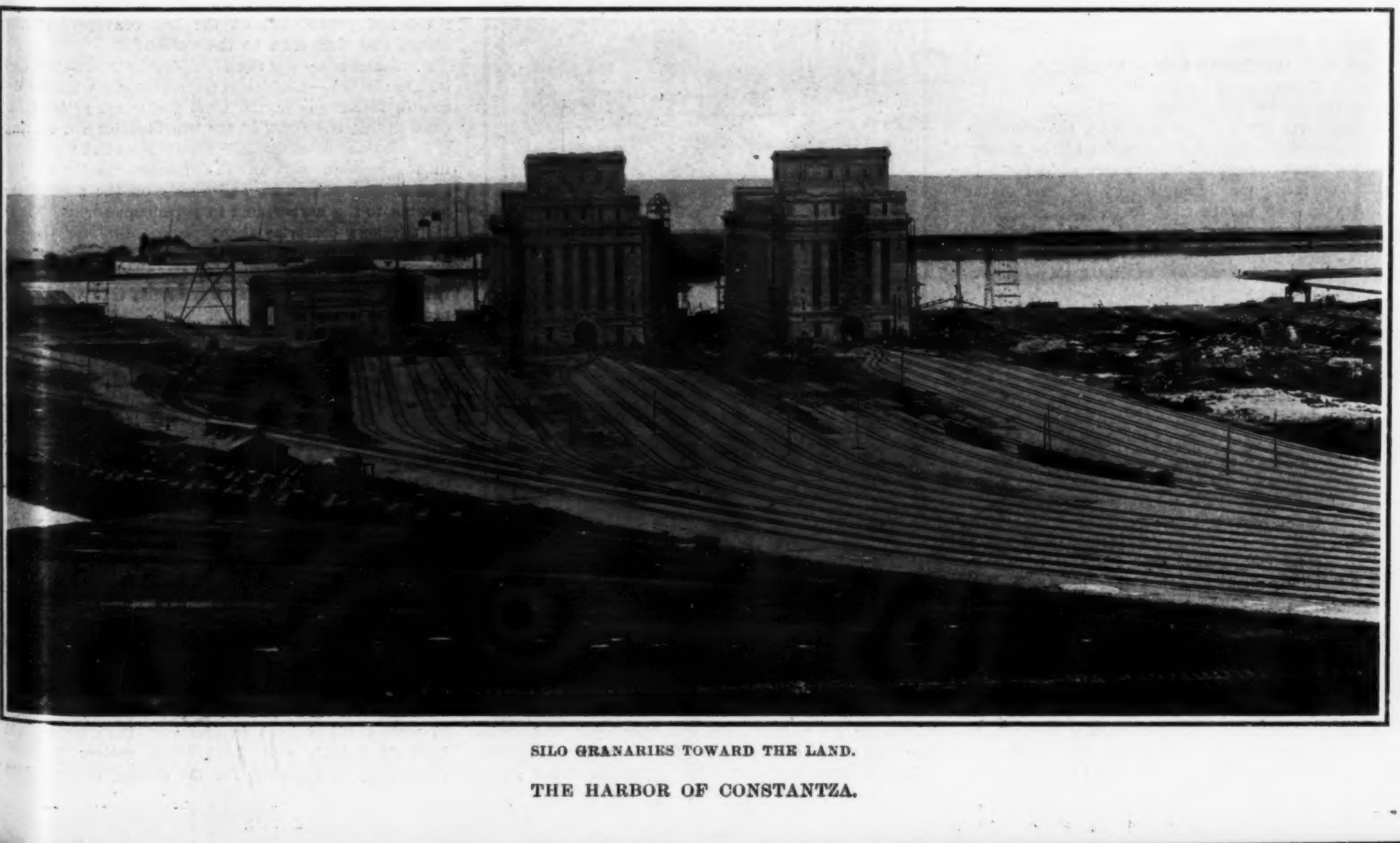
Three piers have been provided to protect the haven against the impact of the waves, viz.: The Broad Pier, 1,377.56 meters (4,195 feet) in length, extending approximately north-south, which protects the harbor against the effect of waves coming from the north and the east, and which are the most powerful. The Southern Pier, 1,496.77 meters (4,911 feet) in length, which runs nearly due east-west. The Entrance Pier, perpendicular to the Broad Pier, which is 119.28 meters (391.3) feet in length.

Between the Southern and the Entrance Piers is the entrance to the harbor, 160.70 meters (527.2 feet) in width. The extreme ends of the piers delimiting the entrance are provided with lighthouses signaling it by night.

From the beginning of the Entrance Harbor south-



SILO GRANARIES TOWARD CONSTANTZA HARBOR.



SILO GRANARIES TOWARD THE LAND.

THE HARBOR OF CONSTANTZA.

ward, the Broad Pier shelters for a distance of 400 meters (1,312.3 feet) the external harbor, where the vessels, being well protected, are enabled readily to take a suitable course for entering.

These piers are erected on a stone foundation on which are resting artificial concrete blocks, each about 36 tons in weight, and arranged in transversal stages. In the part washed by the waves, these blocks consist of concrete made from Pozzolana earth with white lime, whereas those exposed alternately to the water and the air are made of cement concrete. Above the water level the piers are constituted partly by a cement concrete mass cast on the spot, and partly by stone masonry and cement. Their dimensions are as follows:

The Broad Pier, at a level of —10 meters (32.8 feet), is 42 meters (137.8 feet), and at the level of the sea, 11 meters (36.1 feet) in width. The Southern Pier, at —8 meters (26.2 feet) level, is 27 meters (88.6 feet), and at the level of the sea, 8 meters (26.2 feet) in width. The inner harbor, protected by these piers, has quays to an aggregate length of 6,420 meters (22,063 feet), which serve the following purposes:

The quay of the Broad Pier for the Navy and the vessels of the Roumanian Navy Department (747 meters (2,450.8 feet) in length. The quays of the mole for passenger vessels, 520 meters (1,706 feet) in length. The quay, 270 meters (885.8 feet) in length, of the old harbor for piece goods. The Northern quay, 500 meters (1,640.4 feet) in length, for piece [illegible] avy materials and corn. The corn silos [illegible] meters (1,105.6 feet) in length. The corn [illegible] quay, 1,196 meters (3,923.8 feet) in length. The quays 365 meters (1,197.5 feet) in length, of the basin for ship repair and the location of floating harbor utensils. The quays, 948 meters (3,110.2 feet) in length, of the timber mole. The coal mole quays, 514 meters (1,686.3 feet) in length. The quays, 1,398 meters (4,586.6 feet) in length, of the petroleum basin, and the basin for putting out the fires of the tank vessels.

Like the piers, these quays are erected on a stone foundation located in a previously dredged bed, which base consists of several rows of artificial concrete blocks reaching as far as the surface of the sea. From this level, as high as +2.50 meters (+8.2 feet), the quays are made of masonry consisting of unhewn stone and cement. In this masonry a channel has been provided 1.65 meters (4.26 feet) in height, for electric cables and various lines of piping.

Throughout the length of the quay there are arranged pillars and anchor-rings for mooring the vessels; at some places there are stairs for handling the barges.

Inner Harbors: The water sheet encompassed by the piers is 60 hectars (148¼ acres) in area, to which is added the 14 hectars (34.6 acres) area of the outer harbor. This water sheet forms the following basins:

The basin of the quay extending alongside Broad Pier, in front of this quay. The basin of the old harbor, which is bounded by the mole, the piece-goods quay, and the Northern quay. The corn basin, which is bounded by the North quay, the silo quay, and the Northern quay of the corn mole. The timber basin, which is limited by the Southern quay of the corn mole, the quay of the repairing docks of the Northern part of the timber mole. The coal basin, which is bounded by the Southern Quay of the timber mole and the coal quay. The petroleum basin.

These basins are 8.25 meters (27.7) feet in depth below the mean level of the sea, with the exception of the petroleum basin which, because of the greater draught of tank vessels, is 9.25 meters (30.3 feet) in depth. The maximum fluctuation of the level of the Black Sea is —.65 meters (2.13 feet).

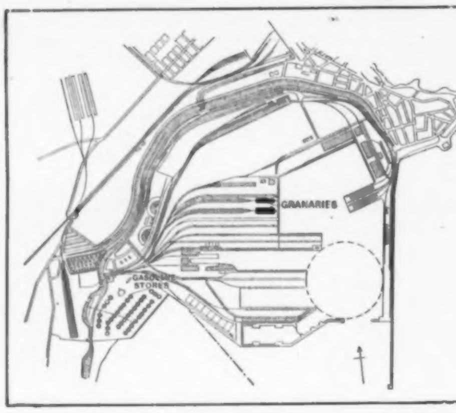
Between the foot of the coast, bounding the keys and the harbor, the latter takes up a ground area of 118 hectars (291.6 acres) which is thus distributed:

The quay range for loading and unloading of vessels, 24 hectars (59.3 acres). The ground taken up by installations for the export of corn and petroleum as well as by the feeding tracks of the various quays and installations, 68 hectars (168 acres). The area reserved for future installations was necessitated by the further development of the harbor 26 hectars (64¼ acres).

The area taken up by the harbor comprises a sufficient number of tracks for connecting together all the quays, the passenger station, the anchoring place for the vessels of the Roumanian Navy Department, installations for the export of corn, petroleum, etc. These tracks are about 60 kilometers (37.3 miles) in total length.

Export Installations. As the transfer traffic shows a marked predominance of export over imported goods, special attention had to be paid to those installations which are intended for insuring an easy and rapid unloading of export goods, the most important of which for Roumania are corn, petroleum and timber, constituting about 85 per cent. of the total traffic.

A.. Corn-Loading Plant. The total equipment provided for the transfer of corn at present comprises: Two granaries, each of which contains 255 silos of a capacity of 35,000 tons of corn; total capacity, 70,000 tons. A plant for the immediate transfer of corn from the railway cars into the vessels without passing through any granaries. An iron frame 570 meters (1,871 feet) in length alongside the silo quay, Northern quay and corn mole quay, with hoppers for use in unloading the corn supplied by belt conveyers into telescoping tubes carried by movable yokes, and thence into the vessels. This frame, being connected by transversal frames with each granary, serves for loading



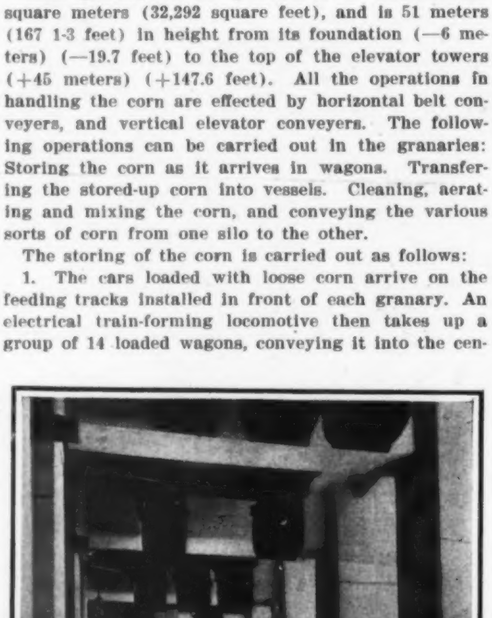
VIEW OF HARBOR IMPROVEMENTS IN CONSTANTZA.

the vessels with the corn stored in the silos or immediately on arriving in wagons. The quays, 570 meters (1,871 feet) in length for the anchoring of the vessels receiving the corn, and the basin provided for maneuvering the ships. These quays will allow five vessels to be anchored for simultaneous loading, and, if desired, even ten vessels can be anchored in two rows.

Each granary takes up an area of about 3,000 square meters (32,292 square feet), and is 51 meters (167 1-3 feet) in height from its foundation (—6 meters) (—19.7 feet) to the top of the elevator towers (+45 meters) (+147.6 feet). All the operations in handling the corn are effected by horizontal belt conveyers, and vertical elevator conveyers. The following operations can be carried out in the granaries: Storing the corn as it arrives in wagons. Transferring the stored-up corn into vessels. Cleaning, aerating and mixing the corn, and conveying the various sorts of corn from one silo to the other.

The storing of the corn is carried out as follows:

1. The cars loaded with loose corn arrive on the feeding tracks installed in front of each granary. An electrical train-forming locomotive then takes up a group of 14 loaded wagons, conveying it into the central granary tunnel, across an iron grate floor, below which are installed the weighing machines, provided with hoppers, which receive the contents of the wagons discharging simultaneously, in order to be removed, and replaced by another set of 14 wagons. Each weighing machine then weighs its contents by recording its weight on a checking card, and drops the corn gradually on the longitudinal belts, which in their turn give it up, by means of two small transversal belts, to the central elevators. The last then raises the corn to the top of the store, distributing it to the upper longitudinal belts, which convey it in front of the silo to be loaded, in order there to drop it by means of a tilting wagon, and a silo-charging tube. The tilting wagons (four to each storing belt) travel automatically over and with the belt, and can be stopped and arrested in front of each charging tube (1 to each silo).



CONVEYER BELTS BELOW THE SILOS.

THE HARBOR OF CONSTANTZA.

2. The transfer of the corn from the silos into the vessels is effected as follows: Through an opening in the lower part of the silos and a hopper car, the corn is conveyed on one of the lower longitudinal belts, which supply it to the elevators on the sea side of the stores. The corn is then lifted to the very top of the store, in order thence to be thrown into automatic weighing machines, which record its weight. It is then conveyed on the belts of the transversal frames, and thence on the belts of the longitudinal frame, which will dump it into the vessels at some point on their way, by means of tilting cars, hoppers fixed to the bottom of the longitudinal frame and telescoping tubes carried by movable yokes installed alongside the quay.

3. *The Cleaning of the Corn* is carried out by means of special machinery in the various stories of the buildings situated on the land side. The corn to be cleaned is supplied by the belts to the elevators of the plant installed on the land side, and after being lifted by these, is distributed to the machines that effect the different cleaning operations successively in a downward direction. Any impurities or sand particles are caught in bags, while the cleaned corn is provisionally stored in two transfer silos, which are specially marked. It then passes over the automatic weighing machines, in order afterward to be stored in the silos, or loaded into the vessels by means of the same elevators and the upper belt conveyers.

The aerating of the corn is effected by conveying it over belts into elevators, then over other belts, and finally back into the same elevators, or some other silo.

The mixing is effected in the same manner, except that the corn runs from different silos simultaneously on belt conveyers, whence it is transferred into different silos or into ships.

The granaries are made of armored concrete throughout. The mechanical equipment warrants for each apparatus, belt and elevator, as well as for each set of cleaning machines an outfit of 150 tons per hour. As the two similar belt conveyers or elevators of the different parts of a granary can be used simultaneously, it is possible also to store in each granary up to 300 tons per hour, while loading the same amount of corn into the vessels.

All the apparatus and machinery are operated by electricity generated at the central station of the harbor.

The installations for effecting an immediate transfer of the corn from the wagons into vessels are located between the two granaries of 35,000 tons capacity each.

Two tunnels, above which the loaded wagons arrive, will supply the corn over belt conveyers to two special elevators erected on the quay, whence it is lifted and poured out on the belt conveyers of the frame, and thence on to the vessels.

B. Installation for the Handling of Petroleum and its Derivatives.—Besides corn, petroleum with its derivates forms one of the most important articles for export. All the installations provided for the storing of petroleum in tanks and its shipment are situated in the western part of the harbor, partly on the ground near the coast, and partly on the ground belonging to the harbor, and in petroleum basins. These installations comprise three plants: One for the receiving and the unloading of trains; another for storing in tanks after unloading the products from the trains; and the third for transferring into vessels the products contained in tanks.

The petroleum trains arrive at a station erected on the coast at a level of +33.5 meters (+109.9 feet). This comprises six feeding tracks of 350 meters (1,148.3 feet) each of which are connected with the railway lines terminating at Constantza. Between these six tracks there are provided four discharging conduits, each of which comprises connecting tubes 3 meters (9.84 feet) apart, and to these are connected flexible tubes, the other ends of which are put into connection with the discharging cocks of the petroleum wagons. Each of these four lines of conduits is destined for some special product (benzine, refined petroleum, distilled petroleum and residues or *pacura*). Each line of conduits is therefore able to discharge a whole train, containing the same product, and is connected with a storage tank of 700 cubic meters (24,720 cubic feet) capacity, into which the products will enter merely under the action of gravity.

At a level of +3 meters (+9.8 feet), 25 tanks 22 meters (72.18 feet) in diameter, 13.40 meters (44 feet) in height, and 5,000 cubic meters (176,570 cubic feet) in capacity, for the storing of petroleum

products, are installed on the harbor grounds. Connection between the upper receiving tanks and these storage tanks is made by three conduits 200 millimeters (7.9 inches) in diameter carried by iron frames across all these tanks. Each line of conduits is set apart for some of the products (benzine, refined petroleum, distilled petroleum), and is connected with all the storage tanks. By means of the cocks fitted to the conduits and the branch conduits leading to the tanks, the liquid can be transferred from each conduit into any one of the tanks.

Four special storage tanks are arranged for the residues, the liquid being discharged from the receiving tanks into the storage tanks by means of a pump, through an underground conduit 250 millimeters (9.84 inches) in diameter.

All the storage tanks are provided on their top with horizontal lids, carrying a water layer 20 centimeters (0.79 inch) in height, which is intended for preventing any gasification of the products contained in the tanks directly exposed to the influence of sun rays.

The tanks are further provided with manholes, safety tubes, overflows, both for petroleum and cooling water, testing cocks and level tubes, for ascertaining the amount of petroleum contained in the tanks.

The transfer of petroleum products into vessels is effected by means of pumps which are installed at the pumping station erected on harbor ground, at 3 meters (9.84 feet) above sea level. This station comprises five double-acting piston pumps. The first three are used for the benzine, refined petroleum and distilled petroleum, respectively, the next serves as a reserve for the same products, and the last of larger dimensions is intended for the residues. All are operated through belt transmission from three benzine motors, two of 30 horse-power each, and one of 50 horse-power. They draw in the petroleum products through conduits connected with the suction tubes of each tank. Cocks and gate slides allow the branch conduits of the remaining tanks to be cut off, to permit the pumps to draw in only from the proper tanks. The same pumps then throw the products through conduits of 1,100 meters (3,609 feet) each, into the vessels loaded in the petroleum tank.

The petroleum tank contains four loading ranges 40 millimeters (1.6 inches) in length bounded by moles. Three of the ranges are provided with benzine, refined petroleum and distilled petroleum conduits, so that these products can be handled at any one of them. The fourth loading range is set apart exclusively for residues, and petroleum products in tins. The mole conduits are connected with the vessels by flexible tubes allowing of a certain motion as produced by the fluctuations sometimes occurring in the basin. The petroleum basin is connected with the rest of the harbor by a passage of 40 meters (131.2 feet) in length, locked by a floating gate for localizing any fire. After reducing their steam pressure in a special basin located in front of the petroleum basin, the vessels are steered exclusively by electrical winches during their entrance and anchoring in the last named basin.

On issuing from the basins, the vessels perform the same maneuvers in a reversed order. During the time the vessels are in the petroleum basin, their crew is put on shore for safety. With a view to this measure of precaution a special building containing dwelling rooms and kitchens for the crew of four vessels is to be erected on the ground.

In order also to facilitate the shipment of petroleum in tins, the construction of armored concrete storage houses has been provided.

In order to insure a ready flow of the residues which are liable to become sluggish in the cold even under the action of pumps, special steam-heating appliances have been provided.

A steam conduit comprising connection tubes at each 9 meters (29.5 feet) distance, has been carried alongside the discharging track for emptying the residues from the wagons. To these flexible tubes are fitted, leading the steam into the wagons; the heated residues thus become more fluid, and capable of a ready discharge.

The receiving tanks and the storage tanks for petroleum residues are provided with serpentines, and their contents are heated by the steam circulating through them. All these conduits are underground, which reduces the heat losses during the outflow of the residues.

The outputs of this plant per hour are as follows: Discharging from the trains and storing in tanks, 720 cubic meters (24,720 cubic feet) of benzine, 610 cubic meters (21,541 cubic feet) of raw petroleum, 200 cubic meters (7,063 cubic feet) of residues.

Transferring into vessels: 200 cubic meters (7,063 cubic feet) benzine, 200 cubic meters (7,063 cubic feet) of ordinary petroleum, 180 cubic meters (6,354 cubic feet) raw petroleum, 100 cubic meters (3,531 cubic feet) of residues.

The petroleum station in addition possesses installations for discharging the products directly into vessels from the receiving tanks. Another plant enables the wagons to be loaded with the products contained in these receivers.

Finally, the petroleum companies possessing at Medea Station (4 kilometers (2.49 miles) distant) special plants for receiving the petroleum trains, have obtained authorization for connecting the plants directly with tanks leased by them in the harbor, in order to convey their products immediately into these receptacles.

C. Plant for Other Export Goods.—No special plant has been provided for use of export goods. These being loaded by means of cranes on board the ships, require no special installations.

Import Installations.—Special yards and sheds for the storing of import articles (coal, rolled iron, sheet metal, railway rails, etc., and use by custom house officials. Furthermore, there is contemplated the construction of storage houses and cellars for goods passing the harbor on their way to other destinations in the country.

The installation of a substantial electrically-operated crane of 50 tons has been provided for unloading the heavy piece-goods, and some other transportable cranes of 2 tons each are installed for the lighter piece-goods.

Accessory Plants.—The energy required for lighting and operating the harbor machinery is supplied by an electric central station erected in the immediate neighborhood of the granaries, the installations of which use up the larger part of this energy.

This power house comprises four sets generating continuous current at 440 volts for power purposes, and at 220 volts for lighting purposes. Each of these sets consists of a Diesel motor for raw petroleum of 400 horse-power output direct coupled to a 270 K. W. continuous-current dynamo. In addition to these sets the power house contains an accumulator battery used as stand-by for the lighting installation during the time the generators are stopped.

The following plants are provided for the cleaning and repairing of vessels and floating utensils:

A slip for vessels of up to 900 tons; a dock 150 meters (492 feet) in length; another 100 meters (328 feet) in length; and the workshops containing all the machinery and equipment required for repair.

In addition to equipments and buildings mentioned, the harbor is to comprise:

An administration building for the harbor service, administration offices, an administration building for the granaries, a custom house, a passenger station, and sheds for the vessels of the Roumanian Navy Department.

Messrs. G. Luther, Ltd., of Brunswick, Germany, have supplied and installed all the mechanical equipments of the granaries and their shipping plants. To this firm the writer wishes to acknowledge his indebtedness for courtesies extended to him in preparing this article.

LOADING BRIDGE WITH CONVEYER BELTS.

THE HARBOR OF CONSTANTZA.

Varnish that Makes No Spots for Paper.—Pour 4.5 parts of acetic acid over 6 parts of gum dammar, in a bottle and allow it to stand for 14 days, at a moderate heat, after which the clear solution is poured off. Three parts of this solution are mixed with 4 parts of thick colodium and the mixture left to clear. To be applied with a soft brush of camels hair or beaver hair.

THE YUKON BASIN

THE water resources available for placer mining in the Yukon-Tanana region will be determined by C. E. Ellsworth and G. L. Parker, who began work in the Fairbanks district in April and later extended it into the Circle district. Mr. Ellsworth will spend the remainder of the season in the Forty-mile district, while Mr. Parker continues the stream gaging in the Circle and Fairbanks districts.

Practically the entire Yukon-Tanana area has been mapped, except a belt lying south of the river west of the Delta. A reconnaissance survey of belt, which contains some extensive lignite deposits as well as gold placers, will be made by J. W. Bagley, topographer, and S. R. Capps, geologist. The party will land near the mouth of Nenana River some time this summer and go southward to the base of the Alaska Range, there beginning a survey which is to be extended eastward to the Delta, covering the Nenana coal field and the Bonnifield placer district. It is expected that this party will carry its work to the crest of the Alaska Range and thus connect with the work of the Moffit and Witherspoon parties south of the range.

The reports from the Innoko placer district are so encouraging as to warrant a continuation of the work done in this field in 1908, the results of which have been published in Bulletin 410 of the Geological Survey. It is now proposed to make a geologic and topographic reconnaissance survey of the more important part of this placer district, including the northern part of the Haiditarod basin. This work will by A. G. Maddren, geologist, and C. G. Anderso rapher. The party will make its way inland of Yukon River, and one section, with seven horses, will be landed at the mouth of Ruby Creek. This section will travel overland to the Innoko and on the way will undertake such surveys as can be made without delaying the party. In the Innoko placer district an areal survey will be begun and carried southward as far as conditions permit. A second section of the party will continue down the Yukon and up the Innoko, bringing supplies to meet the first section of Ophir Creek.

COPPER AND SUSITNA REGIONS.

THE most extensive survey undertaken this year will embrace a region lying between the Gaulkana (a westerly tributary of the Copper) and the upper Susitna. Placer gold has been found in commercial quantities on Valdez Creek and has been reported to occur on other streams in this field. Except for the work of the prospector this region is practically unknown. The plan for this season contemplates a topographic and geologic reconnaissance map of the area lying between the Valdez-Fairbanks trail and the upper Susitna, including the southern slope of the Alaska Range. F. H. Moffit, assisted by B. L. Johnson, will undertake the geologic work in this district. This party will also make a supplementary study of the Chistochina placer district, which has not been examined by any member of the Geological Survey since 1902. D. C. Witherspoon, assisted by C. E. Giffin, will carry on the topographic work. The party will be divided in the field during most of the season. The supplies for these men were transported during the Winter to Paxson, on the Fairbanks trail, and to Valdez Creek.

STEAM TURBINES.—II.*

THEIR DEVELOPMENT DURING THE LAST TWENTY-FIVE YEARS.

BY GERALD STONEY, B.E., M.INST.C.E., M.I.E.E.

Continued from Supplement No. 1806, Page 103.

In my last lecture a short account of steam turbines in general was given; in this one are described various applications of the steam turbine and some things which have conduced to its efficiency.

The design of condensers has been especially influenced by the introduction of steam turbines. As has been shown, in the old days of reciprocating engines, the condenser giving 25" vacuum was quite

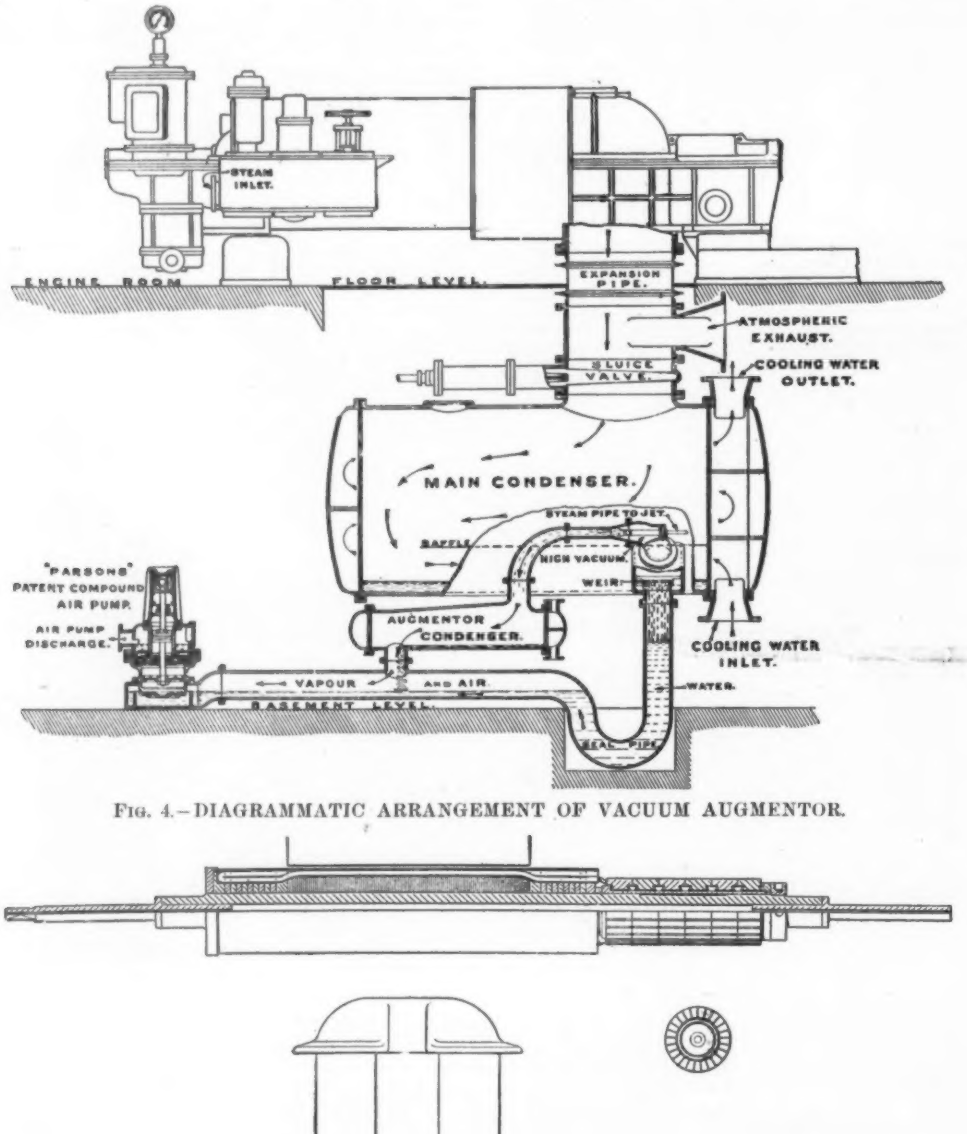


Fig. 4.—DIAGRAMMATIC ARRANGEMENT OF VACUUM AUGMENTOR.

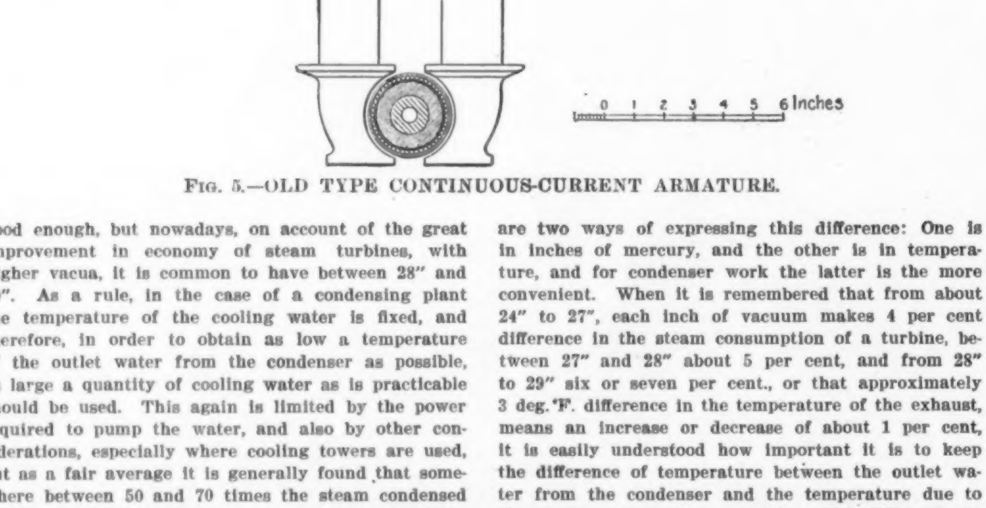


Fig. 5.—OLD TYPE CONTINUOUS-CURRENT ARMATURE.

good enough, but nowadays, on account of the great improvement in economy of steam turbines, with higher vacua, it is common to have between 28" and 29". As a rule, in the case of a condensing plant the temperature of the cooling water is fixed, and therefore, in order to obtain as low a temperature of the outlet water from the condenser as possible, as large a quantity of cooling water as is practicable should be used. This again is limited by the power required to pump the water, and also by other considerations, especially where cooling towers are used, but as a fair average it is generally found that somewhere between 50 and 70 times the steam condensed can be obtained. This means a rise in temperature of the cooling water of about 17 deg. F., as it takes on an average about 1,000 B.T.U. to condense one pound of steam. This figure is rather lower than the one for dry steam, but it must be remembered that exhaust steam is nearly always wet, and therefore takes rather less B.T.U., and we have found in practice that 1,000 B.T.U. per pound of steam is a very fair figure to take.

The maximum vacuum which can be obtained from a condenser is the vacuum due to the temperature of the outlet water, and the closer to this we can get the vacuum actually obtained the better. There are two ways of expressing this difference: One is in inches of mercury, and the other is in temperature, and for condenser work the latter is the more convenient. When it is remembered that from about 24" to 27", each inch of vacuum makes 4 per cent difference in the steam consumption of a turbine, between 27" and 28" about 5 per cent, and from 28" to 29" six or seven per cent., or that approximately 3 deg. F. difference in the temperature of the exhaust, means an increase or decrease of about 1 per cent, it is easily understood how important it is to keep the difference of temperature between the outlet water from the condenser and the temperature due to the vacuum as small as possible. This difference in good modern condensers, when condensing, say 12 lbs., per square foot per hour, can be kept as low as 5 deg. or 6 deg. F.

Another way of looking at the efficiency of the condenser is the B.T.U. transmitted per square foot of cooling surface per hour per 1 deg. F. difference of temperature, and this figure can in well constructed condensers be as high as 1,000 to 1,200 B.T.U. The resistance to the heat passing from the steam to the water may be considered in three stages. There is first the heat transmitted from the steam to the tubes of the condenser, and this resistance is affected by the quantity of air in the condenser, and the efficiency of the air pump. With suitable arrangements, however, this resistance can be reduced to a very small figure, especially if appliances are used such as dry air pumps, or, still better, Mr. Parsons' vacuum augmentor, to withdraw the air completely from the condenser. If air is present it not only vitiates the vacuum, but also reduces the rate of condensation of the steam by, so to speak, causing a blanket of air to form round the tubes, and thus preventing fresh steam getting to them. The second resistance to the transmission of heat is in the metal of the tube itself, but this, with metal tubes, such as are always used, is an exceedingly small figure, and may be neglected. The third and last is the resistance to the passage of heat between the metal of the tubes and the cooling water, and this is apparently one of the principal losses, and varies enormously with the cleanliness of the tube. If there is any slime or dirt or deposit on the inside of the tube it is found that conduction of heat very rapidly goes down, and therefore to get the best results the tubes must be kept clean. In this connection also it is necessary to have sufficient velocity of flow of the water to make turbulent flow in the tubes and not stream line flow, that is, a velocity sufficient to make the water mix up as it is traveling along the tubes and not to have a cold core of water with a hot envelope outside it next the tubes.

It is in this connection with the extracting of air thoroughly from the condenser that the greatest improvements have been made of late years, and among these dry air pumps and the vacuum augmentor mentioned above and shown in Fig. 4, are especially prominent. This latter consists simply of a jet of steam drawing the air and vapor from the condenser and delivering it through a small auxiliary condenser to the air pump, and thus, although the air pump may only produce a vacuum of, say, 27" or 28" there may be a vacuum of 28" to 29" in the condenser, and in practice this appliance has been found most satisfactory. The effect of using this vacuum augmentor has been in some cases to bring up the conductivity from about 250 or 300 to between 800 and 1,000, or to reduce the loss of temperature from some 26 deg. F. to 5 deg. F., a gain in temperature of, say, 21 deg. F., or 7 per cent in the consumption of the turbine.

When it is remembered that the steam jet of the vacuum augmentor only uses about 0.6 per cent of the steam used by the turbine it is easily seen that the gain due to the better vacuum is vastly more than the loss due to the steam jet. This vacuum augmentor is applicable not only to surface condensers, but also to jet condensers with most beneficial results.

One great field for turbines which has only within the last couple of years come into prominence, although it was patented by Mr. Parsons some years ago, is the use of exhaust turbines, that is, turbines taking steam at atmospheric pressure from reciprocating engines or other machinery, and utilizing the power contained in it in an exhaust turbine. When it is remembered that there is as much power in steam working from atmospheric pressure down to a 27" vacuum, as between 150 lbs. down to atmospheric pressure, it is easily seen that the power of an existing non-condensing plant can be more than doubled by the simple application of an exhaust steam turbine and condenser. In cases where cooling water is not available, cooling towers can be fitted, and, of late years, these have been improved so much as to be most efficient pieces of apparatus. Also, in some cases, a further advantage has been obtained in that if the supply of water for feeding the boilers is bad, this bad water can be used in the cooling towers, where it does no harm, and pure condensed water from the turbines can be supplied to the boilers. Such installations are now in use all over the country, and from being absolutely a waste product, exhaust steam has become a most valuable by-product in many works, the exhaust steam being collected

* Journal of Society of Arts.

made to drive turbines and dynamos, and the power either used in the works where the exhaust steam is produced or supplied to other consumers of electricity. In many cases the exhaust steam is intermittent, such as the exhaust steam from a winding engine of a colliery where each time the cage goes up or down there is steam from the winding engine, but in the intervals between the winds, there is none. Such intervals, if not too long, can be bridged over by a thermal accumulator. The principle of thermal storage is itself a comparatively old idea in connection with steam boilers, having been proposed by Druitt Halpin in 1891-92, but the best known form of accumulator for use in connection with exhaust steam turbines is that of Professor Rateau, where a tank containing water has the exhaust steam blown through it so that alternately the exhaust steam is partly condensed, and the water in the tank boils, and thus the supply given to the turbine is constant.

In many cases, however, the stops are too long to be bridged over by any form of thermal accumulator, and in such cases what are called "mixed pressure" turbines have been introduced in which there is a high pressure part revolving idly when exhaust steam is used, but when the exhaust steam supply fails, by an automatic arrangement this high pressure part is supplied with live steam, and thus the turbine continues to be driven. This, also, can be used in conjunction with a thermal accumulator, in such cases as a winding engine, where there are short stops only for a portion of the day, but where there are long stops at week-ends or at times when winding is not going on.

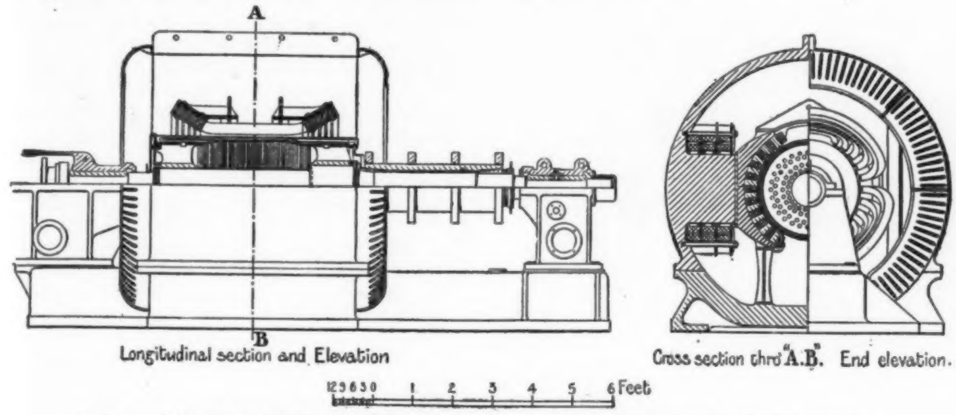


Fig. 6.—O-K.W TURBO-GENERATOR, 480 TO 560 VOLTS, 1,800 REVOLUTIONS.

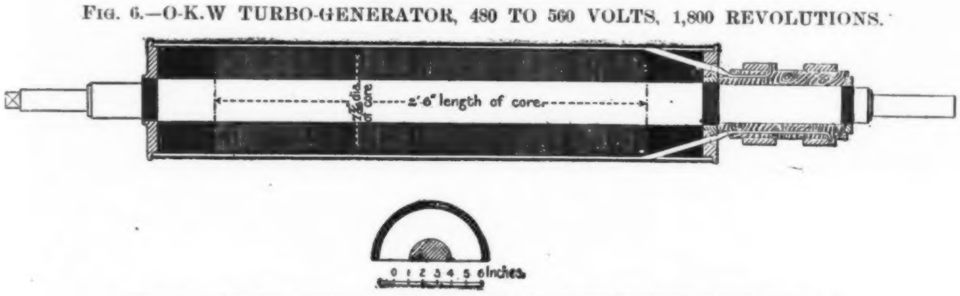


Fig. 7.—75-K.W. SINGLE-PHASE TURBO-ALTERNATOR ARMATURE.

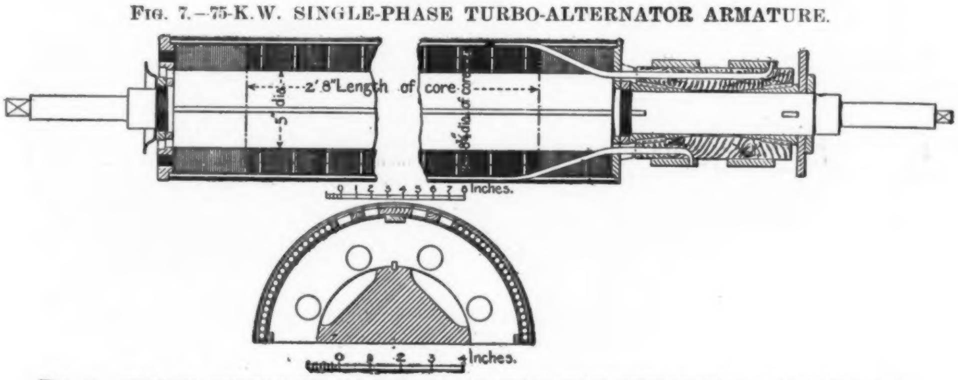


Fig. 8.—150-K.W. SINGLE-PHASE TURBO-ALTERNATOR ARMATURE, SHOWING AIR-COOLING DUCTS.

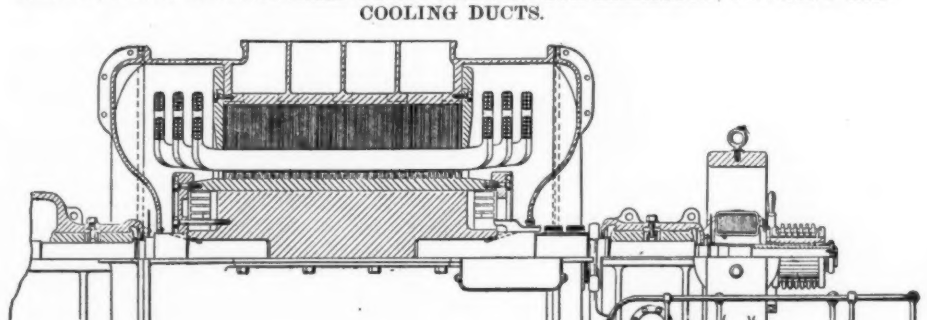


Fig. 9.—4,000-K.W. THREE-PHASE TURBO-ALTERNATOR WITH EXCITER 6,000 VOLTS.

This arrangement of turbine to be able to utilize economically either exhaust steam or high pressure steam has probably a great future before it, and it is one of the remarkable things about a turbine that it has so much flexibility that such an arrangement is possible—in fact, it has been found that such mixed pressure turbines are within 5 per cent as economical as either a pure turbine for using high pressure steam alone or a pure turbine for using exhaust steam alone.

The first applications of the steam turbine to driving machinery were in the driving of electrical machinery, and on land this still continues to be the greatest use for steam turbines. Twenty-five years ago, when Mr. Parsons made his first high speed dynamo, the usual speed of revolution was for dynamos, as a rule, from 1,000 to 1,500 revolutions per minute, and they were generally belt-driven from the engine.

Mr. Parsons made his first high speed dynamo (see Fig. 5), to run at a speed of 18,000 revolutions per minute, and it was for a power of about 10 horse-power. This increase of speed to from ten to fif[illegible] times that of ordinary dynamos necessitated a [illegible] careful consideration of the design, both from the electrical point of view and also to meet the enormous centrifugal forces which would be engendered. These latter were met by a drum armature with spiral end winding, the whole held together by binding wire, and the construction of the commutator segments in short lengths, dovetailed into steel rings with asbestos insulation. The diameter also was kept small, and the

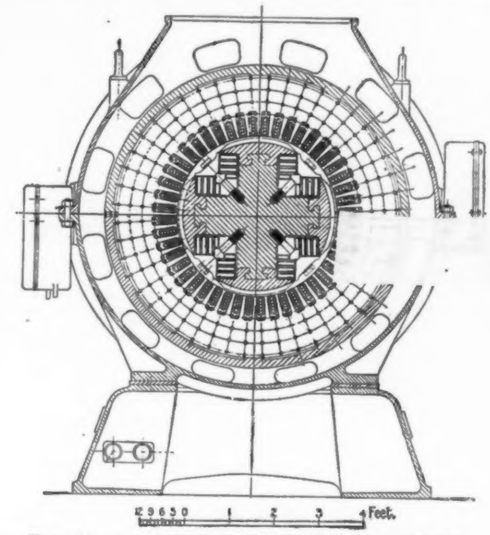


Fig. 10.—4,000-K.W. THREE-PHASE TURBO-ALTERNATOR, 6,000 VOLTS. (CROSS SECTION.)

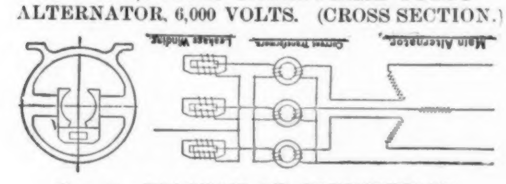


Fig. 11.—DIAGRAM OF CONNECTIONS. (LEAKAGE WINDING.)

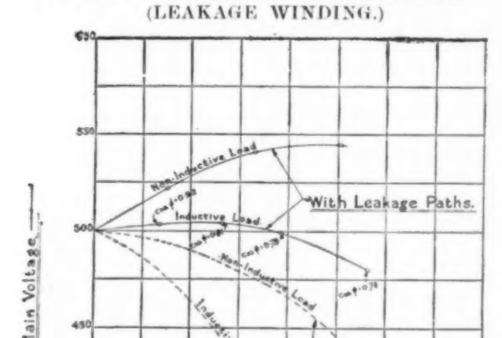


Fig. 12.—450-K.W. TURBO-ALTERNATOR VOLTAGE REGULATIONS PUTTING ON LOAD. (RHEOSTATS UNALTERED.)

core and commutator were relatively of considerable length. In all turbo-dynamos the core lengths are large and the diameter comparatively small, in order to prevent stresses due to the centrifugal force being excessive.

Some of the difficulties to be met with in turbo-dynamos will be understood if we compare a slow speed two-pole dynamo of 50 kilowatts per 300 revolutions per minute, with a turbo-dynamo of 500 kilowatts, at 3,000 revolutions per minute, also two-pole. Here we have ten times the speed of revolution, ten times the surface speed, and 100 times the centrifugal force to contend with. The output in kilowatts is proportional to the speed, or ten times, but as the former was for 110 volts and the latter for 550, we had to have only half the number of segments, so that the voltage per segment is ten times. The frequency of the commutation is five times as great therefore,

and the reactance voltage on which the sparking largely depends is fifty times as great; and finally the hysteresis and eddy loss in the armature core will be somewhere about sixteen times as much.

It is thus seen that special arrangements will have to be made to meet the very special conditions of a turbo-dynamo. The core loss has to be taken care of by very special ventilating arrangements to enable the heat to be carried off; and centrifugal force is met by employing the best materials and most careful construction. The voltage per segment in the commutator and the reactance voltage, the two principal things which govern commutation, are met with by the provision of either commutating poles or compensating winding, or a combination of the two. In our experience we have found compensating winding alone most satisfactory, and the adoption of such compensating winding enabled a dynamo with such winding to be increased in output from about 200 kilowatts to 500 kilowatts, and that without any shifting of the brushes such as was formerly necessary. Fig. 6 shows a 750 kilowatt turbo-generator built on the lines described above, and this can carry overloads of 50 per cent without sparking of the brushes, or having to shift them in any way.

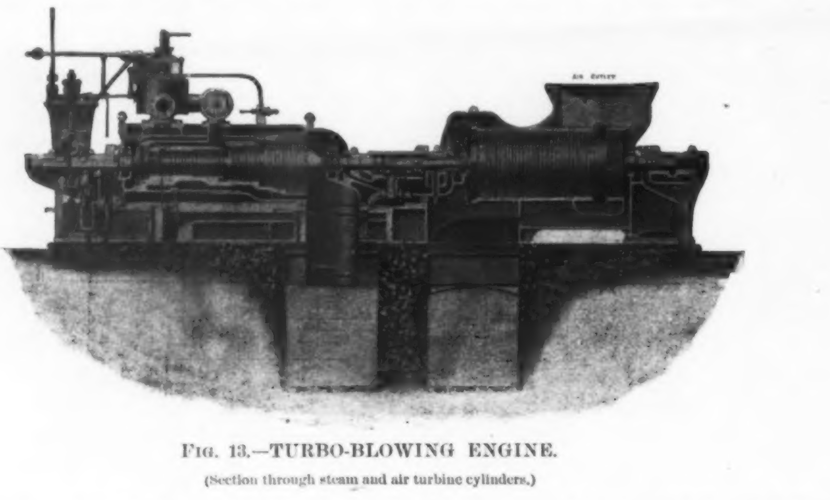


Fig. 13.—TURBO-BLOWING ENGINE.

(Section through steam and air turbine cylinders.)

I may further say that we have found in our experience two-pole turbo-dynamos to be much more satisfactory than four-pole, and to cost little more to build, the two-pole proving to be much less liable to flash over than the four-pole; in fact with our modern two-pole turbo-dynamos such a thing as flashing over is unknown.

Turbo-alternators were started rather later than turbo-dynamos, the first being made about 20 years ago for the Newcastle and District Electric Lighting Company, Limited, four sets being installed in their Forth Banks station. These early alternators consisted of a smooth core having the windings laid over it and held on by binding wire, the ends being connected to slip rings, and were as a rule single phase. The size gradually increased up to 1,000 kilowatt single phase, and a voltage of 4,000 volts. Two of these early machines are shown in Figs. 7 and 8. It was found, however, that with high voltages, and especially when two or three-phase alternators had to be built, the difficulties of manufacture and of insulation were very great, and therefore the type with revolving field magnets was adopted. Figs. 9 and 10 show a 4,000 kilowatt three-phase turbo-alternator for 6,000 volts, 40 periods, running at 1,200 revolutions per minute, and I may say that eight of these are installed in the Carville Power Station of Newcastle-Upon-Tyne Electric Supply Company, Limited, in connection with the great power distribution in the North of England. The stator is of the usual type of laminated iron, the only noticeable point being that the end windings have to be very firmly stayed to stand up against the very heavy stresses which are occasioned if there is a short circuit or other sudden rush of current. The rotor consists of a steel casting with forged steel pole tips, the coils being separately wound and slipped on in place, after which the pole tips are put on and strong nickel steel bolts with manganese bronze keeps are used to counteract the tangential component of the centrifugal force. This rotor may be said to be typical of what is called the "salient pole formation," but there is also what may be called the "barrel" or "drum" type, which was first introduced by Mr. C. E. L. Brown, of Baden, Switzerland, in which the rotor consists of a series of plates with the winding embedded in slots in the outer circumference. It is a moot point which form is best, some having advantages in one way and some in the other, and which will eventually survive depends both on case and cost of manufacture as well as mechanical and electrical advantages, and up to the present this point has not been settled. As in the case of continuous current machinery, one object is to get the maximum output at the highest speed possible, and since the materials available limit the length and diameter of rotor and therefore the available flux and the ampere turns, these again limit in the stator the output which can be obtained with a certain inherent regulation.

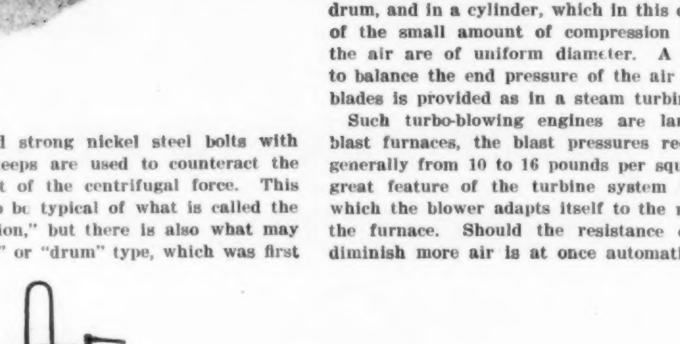


Fig. 15.—SHOWING PORTIONS OF THE EXHAUSTER CASING REMOVED SO AS TO EXPOSE THE PROPELLER AND GUIDE BLADES.

A much larger output can be obtained by the adoption of some form of compounding which enables regulation again to be made as good as is desired. There are several means of doing this, one which is often used being the "Tirrill" regulator, where moving contacts regulated by the voltage of supply alter the excitation of the alternator. Another method which we have largely used is what we call a leakage path winding, shown diagrammatically in Fig. 11, and this is a small yoke being put across the poles of the exciter round which the main current passes, and when this current increases it chokes back the magnetism and thus raises the voltage of the exciter. The effect of it is shown in Fig. 12, where will be seen the great difference in the regulation of the alternator with or without leakage paths.

An important development during the past few years has been the application of the steam turbine for driving air compressors. An ordinary steam turbine when driven backwards does not act as an air compressor, but if the blades are suitably shaped it forms a very efficient one, and this fact has led to a large development in the application of steam turbines.

A section through such a compressor combined with its turbine is shown in Fig. 13, and it is seen that the compressor is very similar in construction to the steam turbine, having blades fixed on a revolving drum, and in a cylinder, which in this case on account of the small amount of compression to be done on the air are of uniform diameter. A dummy piston to balance the end pressure of the air on the moving blades is provided as in a steam turbine.

Such turbo-blowing engines are largely used for blast furnaces, the blast pressures required ranging generally from 10 to 16 pounds per square inch. One great feature of the turbine system is the way in which the blower adapts itself to the requirements of the furnace. Should the resistance of the furnace diminish more air is at once automatically delivered by the turbo-blower without the possibility of the engine racing. In fact the speed of revolution remains quite constant over a wide range of duty. Should, on the other hand, the resistance of the furnace increase, the quantity of air will be diminished and the pressure automatically increased. When what is known as "hanging" takes place it is an easy matter to speed up the turbine engine until the furnace is blowing freely. Usually about twice the normal working pressure can be obtained by this method.

Iron masters who use turbo-blowers find that they can always get more iron from the furnaces when a turbo-blower is supplying the blast than when it is supplied from a reciprocating engine. It is thus seen that the great elasticity and adaptability of such engines together with the steady blast is a great advantage in metallurgical work.

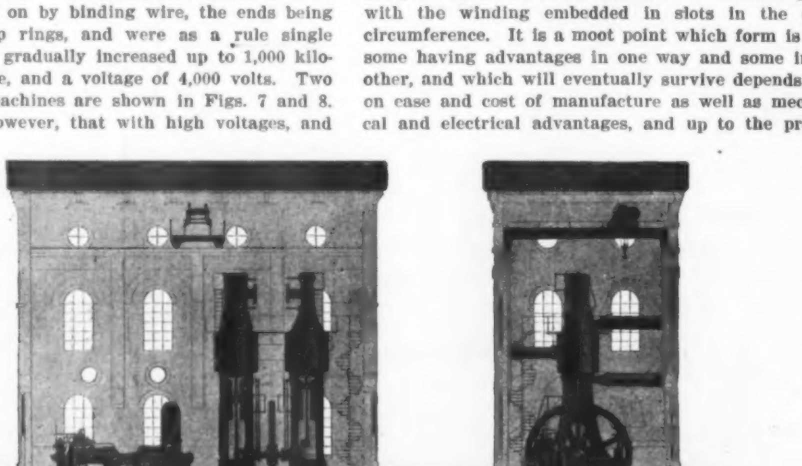


Fig. 14.—INSTALLATION OF TURBO-BLOWING ENGINE AND CONDENSER.

(Showing the saving of space occupied by turbine over the reciprocating engine of equal output.)

Fig. 14 shows an engine room in which both ordinary reciprocating blowing engines and turbine blowing engines are installed. The reciprocating engine is somewhat smaller in output than the turbine, and it is at once obvious what an enormous saving in space is effected by the use of the turbine engines. Further, it may be mentioned that the weight of the turbo-blowing engine complete is 25 tons, and the weight of the reciprocating engine 430 tons, or nearly seventeen times heavier than the turbine.

A very useful size of plant is that built to deliver 20,000 cubic feet of free air per minute at 10 lbs. to 15 lbs. blast pressure. This size is suitable for blowing the average English blast furnace, and takes about 15,000 lbs. of steam per hour at 150 lbs. steam pressure, 100 deg. superheat, and 28½" vacuum, barometer 30". From these figures it may be seen that turbo-blowers are exceedingly economical. Besides iron smelting turbo blowers are used for copper refining and other metallurgical work. Small size turbo blowers are often driven by electric motors running at high speeds.

For producing pressures higher than 25 lbs. per square inch, the design of the blowing engine is usually of the centrifugal type, and consists of a

number of centrifugal fans specially constructed to withstand the stresses caused by the high speed of revolution. The fans are arranged to blow in series, the pressure being slightly increased at each fan until the desired pressure is obtained, and in this way blowers are built to give 80 lbs. pressure and above. This type of machine is used principally for mining operations, such as supplying compressed air for rock drills and coal-cutting machinery, and is found to be very economical.

The fans are generally arranged in two cylinders, a high and a low pressure, with an intercooler between them. The air is also cooled during compression by water-jacketing the cylinder.

A further development of the turbo-compressor is for dealing with large volumes of gas or air at low pressures, and a number of this type designed to deal with about 30,000 cubic feet free air per minute at about 1 lb. pressure have been made. They are used principally for drawing exhaust gases from blast furnaces, and driving them through the by-product recovery plant. The gases from blast furnaces, more especially the Scotch blast furnaces, where coal is used instead of coke, are heavily charged with tar, ammonia, etc., and the usual form of reciprocating compressor has been found to be very troublesome, due to choking up, but since the turbo-machine came out, most gratifying results have been attained, the plants running for many months, night and day, without ever being shut down.

Another application is that of boosting up the pressure of coal gas in the gas mains of large towns. Sometimes it is found that owing to the extension of a town the mains become too small. The introduction of small turbo blowers enables a large amount of gas to be forced through the small mains, and thus saves the heavy cost required to lay down additional mains to meet the increased demand for gas in the outlying districts.

In the Glasgow Corporation Gas Works, a small turbo-blower is used for pumping gas down hill; this may seem rather paradoxical, but it must be remembered that coal gas is lighter than air, and therefore it has to be pushed down hill by mechanical means. The construction of this latter type of blower or exhauster as the case may be, is shown in Fig. 15. It will be seen that the particular machine illustrated consists of three screws, very much like the propellers of a ship, only having more blades. Between the propellers, spiral guide rings are fitted. The power required to drive these machines is generally about 150 horse-power, and the speed of revolution about 7,500 revolutions per minute, varying of course with the size and duty of the engine.

A NEW DEPARTURE IN TWO-STROKE ENGINES.

ONE CYLINDER EQUIVALENT TO FOUR.

A somewhat novel type of two-stroke gasoline engine embodying some interesting features has been designed by Mr. G. Enderby and Mr. H. Johnson, A.I.M.E., of Harrogate, and is known, says the Practical Engineer, as the Enderby-Johnson engine. Fig. 1 shows a section of a single-acting engine constructed according to this design, while Fig. 2 is a section through a double-acting engine.

Referring to Fig. 1, *a* is the working cylinder and *b* the pump cylinder (of slightly larger diameter than *a*) and a^1 b^1 are the pistons in them; *c* is the hollow piston rod having in it ports a^2 b^2 opening respectively into the cylinders *a* and *b*. The ports b^2 are always open, but the ports a^2 are closed in all positions except the one shown by the sleeve *d*, forming a guide in which the piston rod *c* works. In the position shown the ports a^2 coincide with the ports d^1 in the sleeve *d*, and the cylinders *a* and *b* are therefore in communication with each other. c^1 is a packing ring to make a tight joint between the piston rod *c* and the sleeve *d*, which, it will be observed, is made sufficiently long to prevent the piston ring from escaping. a^3 are exhaust ports in the cylinder *a*, and b^3 are induction ports in the cylinder *b*; *e* is a hole for the insertion of a firing plug.

When the piston a^1 of the working cylinder *a* is in the position shown, the cylinder is receiving a charge of compressed gas from the cylinder *b*; by such time as it has traveled a very short distance on the up stroke, the port a^2 in the piston rod *c* delivering the charge into the cylinder *a* is closed, and immediately afterwards the piston a^1 passes over and closes the exhaust ports a^3, sealing the charge in the cylinder *a*, and compresses it until the top of the stroke, when it may be fired electrically or otherwise. At the same time that the piston a^1 is compressing the charge in the cylinder *a*, the piston b^1 in the cylinder *b* is moving upwards, creating a vacuum inside the cylinder until it uncovers the ports b^3 of the induction pipe just before the end of its stroke, when the vacuum created inside the cylinder *b* causes it to fill itself immediately with carburetted mixture. When the piston b^1 begins to travel downwards the piston ring passes over the induction ports b^3, closing them, and the mixture is compressed.

The cylinder *b* is of larger diameter than the working cylinder *a* to allow it to pump sufficient mixture to fill the cylinder and combustion space in the cylinder *a* with pure mixture.

To return to the operation of the cylinder *a*, the ignition and explosion has taken place, forcing the piston a^1 on its downward stroke; this it continues to do until nearing the bottom, when the piston passes and opens the exhaust ports a^3, when the exhaust gases immediately escape. Just before the piston gets to the end of its stroke, the ports a^2 in the piston rod deliver a compressed charge of carburetted mixture from the cylinder *b* into the cylinder *a*, charging the same for the next cycle.

This engine will work equally well in either direction.

Referring to Fig. 2, the lower part of the cylinder *a* and the upper part of the cylinder *b* work together exactly as described with respect to the other ends of the cylinders in Fig. 1; but since the end of the hollow piston rod *c* now opens into the cylinder *b*, ports open are dispensed with. The hole for the firing plug in the lower end of the cylinder *a* is not shown. As before, the cylinder *b* is of greater volume than the cylinder *a*. The adjacent ends of the cylinders *a* and *b* are put into and out of communication with each other as follows: The upper end of the piston rod *c* is of less diameter than the lower end, so that in the position shown there is an annular passage *f* between the piston rod *c* and the upper end of the sleeve *d*, and at the bottom of this passage there are ports d^2 opening into the upper end of the cylinder *a*, such ports being uncovered, as shown by the piston rod *c*, when the pistons are in their lowest positions, thus allowing the compressed explosive mixture in the lower end of the cylinder *b* to pass into the upper end of the cylinder *a* and sweep out the products of combustion through the exhaust ports a^3. As the piston a^1 rises, the piston rod *c* first closes the ports d^2, and immediately afterwards the piston itself closes the ports a^3.

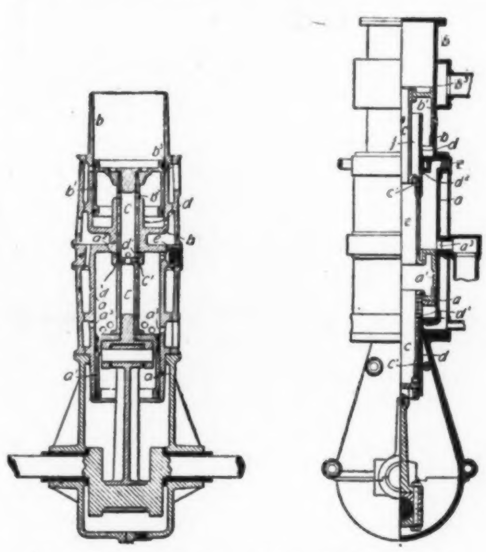


Fig. 1.—Single-acting engine. Fig. 2.—Double-acting engine.

THE ENDERBY-JOHNSON TWO-STROKE ENGINE.

Many advantages are claimed for this type of engine over the four-stroke engine. For instance, one cylinder of the new type is equal to four of the old in number of explosions per revolution of crank, with a consequent saving of approximately 75 per cent space, and omitting the flywheel on each type of more than 50 per cent in weight and of about 66 per cent in cost of production. There are three working parts only, as against not less than 46 moving and wearing parts in the present type four-cylinder engine, and a consequent reduction in chance of breakdown and friction through bearings of extra wearing parts in Otto cycle engine and lifting of strong valve springs, the only three moving and wearing parts in the new engine being internal. The new engine is most positive in its action, and absolutely automatic by movement of the piston in the cylinder, quite devoid of any valve or any moving part of any kind, either internal or external. The complete scavenging of all residue of exhaust gases is effected by the pumping of a new charge into the cylinder at the firing point at combustion end of the cylinder. For that reason it is found that in comparison with other engines the engine runs on a very much weaker mixture, the gas with the air being drawn into the pumping cylinder and forced through the holes becoming thoroughly atomized previous to ignition.

The engine runs either way, no matter how many cylinders; each unit of 3 multi-cylinder engine is entirely independent of any other and is self-timing. Its advantages for motor boats and flying machines lie in the great saving of space and weight which would be effected by its use. The engine may be likened in some degree to a double-acting steam engine, the piston being cushioned at each end of its stroke; the engine therefore runs with remarkable balance and even turning movement. Using the hollow piston and rod as a passage for the gas to the bottom end of the working cylinder assists materially in keeping these parts and the guides cool. Some excellent results have been obtained with experimental engines of this type.

ELECTRIC LIFTS ON SHIPBOARD.

The White Star liners Olympic and Titanic are each to be fitted with three first-class passenger lifts arranged in one trunkway, and one lift for second-class passengers. Each of the first-class lifts will raise 15 hundredweight, from the upper deck to the promenade deck, a distance of 37½ feet, and will travel at a speed of 100 feet per minute. The size of the cages will be 5 feet 4 inches wide by 6 feet 7 wide. In addition to the usual safety appliances, a special safety gear is provided on each cage to guard against excessive stretching of the suspension ropes. It consists of four steel cams connected by levers, and arranged to come into operation and grip the guides. This apparatus will be actuated by the opposing pull of the ropes, and will not depend upon springs, but in the event of simultaneous failure of both suspension ropes, the safety gear would be brought into action by means of an independent safety line. The guides for cage and counterbalance will be of turned steel, and the cage and weight fitted with adjustable gunmetal guides. The motors will be of the four-pole, totally-enclosed, shunt-wound type, rated at 6 B. horse-power when running at a speed of 500 revolutions per minute, coupled direct to machine-cut worm and wheel-winding gear.—The Practical Engineer.

SEWARD PENINSULA.

The surveys and investigations of Seward Peninsula are more nearly complete than those of any other part of Alaska. Reconnaissance surveys have been carried over the entire peninsula and detailed geologic and topographic surveys have been made of some of the most important mining districts. In addition, stream gaging has been done during the past four years, so that fairly reliable data are available regarding the quantity of water that may be used for placer mining. In view of the demand for work in other parts of Alaska it is not now possible to continue work in this region, but as it is desirable to keep some records of the stream flow a few gaging stations will be maintained in the peninsula during the Summer, and G. L. Parker, the stream gager, will spend a few weeks in the Fall in visiting these stations.

The conditions under which a street lamp should prove its efficiency are very different from those which govern the indoor lamp. This was brought out clearly in a recent address before the New York section of the Illuminating Engineering Society by Dr. Clayton H. Sharp. He pointed out that while in the building it is advantageous to have much of the light of a lamp pass upward and be reflected by the ceiling, in the case of a street lamp this would be a great fault, for the vertical rays would be lost. Only those rays that are cast directly downward and horizontally up and down the street can be utilized. For this reason he has devised a reflector consisting of a pair of parabolic mirrors arranged to throw the rays in the direction of the street, so that practically all of the light will be used to best advantage. Thus, in place of having the street lighted in spots, as is now the case, a more continuous illumination is provided.

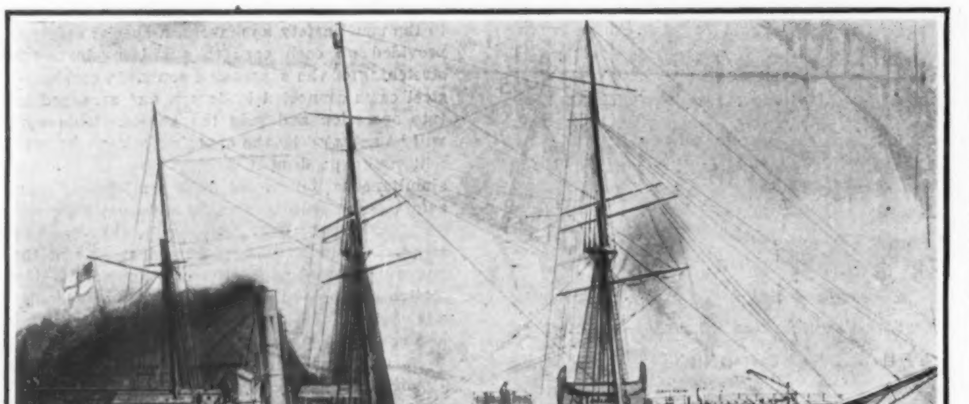
THE QUEST OF THE UNDISCOVERED SOUTH POLE.

THE DEPARTURE OF THE "TERRA NOVA" FROM LONDON.

On the morning of June 1, the "Terra Nova," which ship bore the officers and equipment of the British Antarctic expedition to its winter quarters on the South Polar continent, left the West India dock and sailed away down the Thames over the first few miles of its long journey. On May 27, Captain Robert Scott told a crowded audience at the Royal Institution his plan for reaching the South Pole. After giving particulars, which are summarized in tabular form here, Captain Scott proceeded to say that "during the winter preparations will be made for a great effort to reach the South Pole in the following season. We know now that the first phase of that journey must be over the plateau of the Great Barrier, the second a climb through mountain passes, and the third a traverse of a lofty inland plain. It is only possible, certainly not probable, that any means of transport can be taken beyond the first phase. If it is impossible then we shall have, as had Sir Ernest Shackleton, to make all further advance with the unaided efforts of man alone. Shackleton's party started on the second phase with full loads, and achieved what is probably the maximum that could be accomplished under such circumstances. The only manner, therefore, in which such a record can be beaten is by taking a larger party of men and sending sections of them back at intervals. This is, of course, a well-known expedient in polar work, but it has to be remembered that each multiple of the original number of men only adds a fraction, and a diminishing fraction, to the radius of action. In other words, a party with the aid of a supporting party of equal numbers can only hope to achieve a distance one-third greater than it would have done without a supporting party. Taking this fact into consideration, together with the increased risk of individual break-downs which the larger number of men must bring, it must be evident that the achievement of the South Pole, in view of the distance which has to be traversed in the second and third phases of the journey, is by no means a certainty. Of course, one is not without hope that either the ponies, the dogs, or the motor sledges may traverse the disturbed regions of the glacier, and if this is possible the difficulty of the journey should be greatly diminished. But even so, it must be remembered that the last phase of the journey, owing to the height of the plateau, has to be accomplished under climatic conditions which for severity are unequaled either in the Arctic or Antarctic regions."

THREE STAGES OF THE ATTEMPT TO REACH THE SOUTH POLE.

First: From headquarters in McMurdo Bay across the Great Ice Barrier; 380 miles of flat-going with ponies, dogs and motor sledges. **Second:** Up the great Beardmore Glacier, possibly with the ponies or dogs; length of glacier 220 miles. Third: Across elevated plateau, 11,000 feet high, against constant South wind and low temperatures; distance to be covered some 250 miles. **South Pole: Situated 860 miles from** McMurdo Bay, which is over 13,000 nautical miles from London.



THE "TERRA NOVA" PREPARED AND PROVISIONED FOR HER GREAT JOURNEY.
A fore-and-aft section. (From the Illustrated London News).

The numbers refer to the following: 1. Piano. 2. Pantry. 3. Instrument room. 4. Engineer's berth. 5. Evaporator for fresh water. 6. Ventilator. 7. Stove. 8. Biologist's locker. 9. Boatswain's store. 10. Carpenter's store. The motor, sledges and dogs are to be taken aboard at Lyttelton. The dogs will probably occupy the forecastle.

THE QUEST OF THE UNDISCOVERED SOUTH POLE.

From the time table of the expedition given below it will be noticed that the western party spend nearly seven months on the "Terra Nova" and the eastern party nearly nine months. Captain Scott joins at Lyttelton and will thus spend nearly three months on the vessel.

HOW CAPTAIN SCOTT MAPPED OUT AS FAR AS WAS POSSIBLE THE TIME TABLE OF THE BRITISH ANTARCTIC EXPEDITION.

Departure from London	June 1, 1910
Cardiff	June 15, 1910
Cape Town	August 1, 1910
Melbourne	September 13, 1910
New Zealand	October 13, 1910
Leave New Zealand	end of November, 1910
McMurdo Sound	end of December, 1910
Landing of winter hut and provisions of western party (twenty-two to twenty-five persons in number)	December 22, 1910
Starting off of this party	about January 21, 1911
King Edward's Land reached, if possible, early in	February, 1911
Establishment of second hut and traveling equipment for party of six men on King Edward's Land	February, 1911
Caches of provisions to be left on edge of Great Ice Barrier to form link between eastern and western parties	February, 1911
"Terra Nova" to turn northwards about	February 21, 1911
Investigation of the pack in the region of the Balleny Islands, and to proceed to the westward through, or to the south of, those islands	March, 1911
Depots laid well to the south on the Great Ice Barrier	April, 1911
Start for the South Pole to be made during the month of	October, 1911
Barrier to be traversed and the Beardmore Glacier ascended	during October and November, 1911
Upper plateau to be reached early in December, 1911	
South Pole to be reached, if possible, on	December 22, 1911

Captain Scott declared to the audience that he was taking with him on his journey to the South Pole instruments which would determine the position of the Pole within the limits of one mile. He had, he added, no hesitation at all in making that statement. The excellent instrumental equipment of the expedition accounts for Captain Scott's certainty on this point, a very interesting one in view of the recent controversies which raged round the question of the discovering of the North Pole. The instruments which are being taken by Captain Scott have been supplied by the firm of Hughes & Son, opticians of Fenchurch Street. The photographic illustrations given here show the instruments which will be used by the expedition in the position in which they are customarily held while an observation is being taken. In determining one's position by an instrument the most important factor to be arrived at is the height of the sun above the horizon at noon. This is done by measuring the angle made by the sun, the eye of the observer, and the horizon. In other words, one has to draw a line from the sun to the eye and from the eye to the horizon, and measure the angle which these two imaginary lines make. In a sextant this is done by means of a movable mirror attached to a graduated scale, which gives the angle required. The image of the sun in the mirror is brought down to the edge of the horizon or other level employed. The ordinary sextant is held in the hand and is probably not so reliable as the theodolite which Captain Scott used on his former journey and which he is using again. This is fixed to a tripod and gives very reliable results. At sea a captain observes the altitude of the sun by bringing it in contact with the horizon where sea and sky meet by means of the little mirror which can be moved by the hand. An artificial horizon is used on land where the surface is irregular. For this purpose a little tray of mercury is often used; but this is not possible in the Antarctic, where the temperature would freeze the mercury.

It must be remembered that during their sledge journey to the South the party will have the sun at their backs, i. e., in the North, and that the sun will reach its own highest point in the heavens on December 22nd, the mid-Summer day of the Antarctic continent. The Summer period—the period in which the sun is visible—lasts from September 22nd to March 21st. It should be noted that Capt. Scott does not intend to start his journey to the South until some time in October, thus allowing the sun time to get well clear of the horizon.

Very special equipment is being taken by the expedition in order to record photographically everything of interest and importance which they may encounter. The artistic work of Mr. Ponting, who is in charge of this department, will be well known. For use on the sledge journeys cameras of metal, and specially light and strong, have been made. Two cinematographs are being taken.—The Sphere.

Stock and Heynemann have succeeded in fusing calcium, cast iron and crystallized silicon by means of the concentrated rays of the sun. The substances were placed in a little crucible of magnesia, inclosed in a

thin glass globe from which the air was exhausted. The solar rays were converged upon the crucible by a common lens of 1.6 inch diameter and 2 inches focal length. Crystallized silicon, the fusing point of which is 2,640 deg. F., was melted in a few seconds. It is necessary to operate in vacuo in order to obtain very high temperatures. In one experiment a thermo-electric couple placed at the focus of the lens in vacuo indicated a temperature of 1,886 deg. F., but the temperature fell to 1,247 deg. F. when air was admitted to the globe.

ARTIFICIAL RUBBER.

WHEN the 70,000 tons of rubber, at which the present annual production of the world is estimated, are valued at figures ranging from twenty-five million pounds to upwards of double that amount, the claims that artificial caoutchouc—not rubber substitutes, whose number has been increasing for years—has finally been prepared synthetically naturally cause a considerable stir. Nearly half of all the rubber collected passes into or through the United Kingdom. Rubber is wanted in almost every industrial branch; the natural production has not kept pace with the demand, and the engineer, even if not engaged in electrical enterprise, cannot dispense with rubber, and is interested in its industry. Scientists have for years been attempting to solve the problem of the synthetical preparation of rubber; but it is only quite recently that large works have seriously taken up artificial rubber processes.

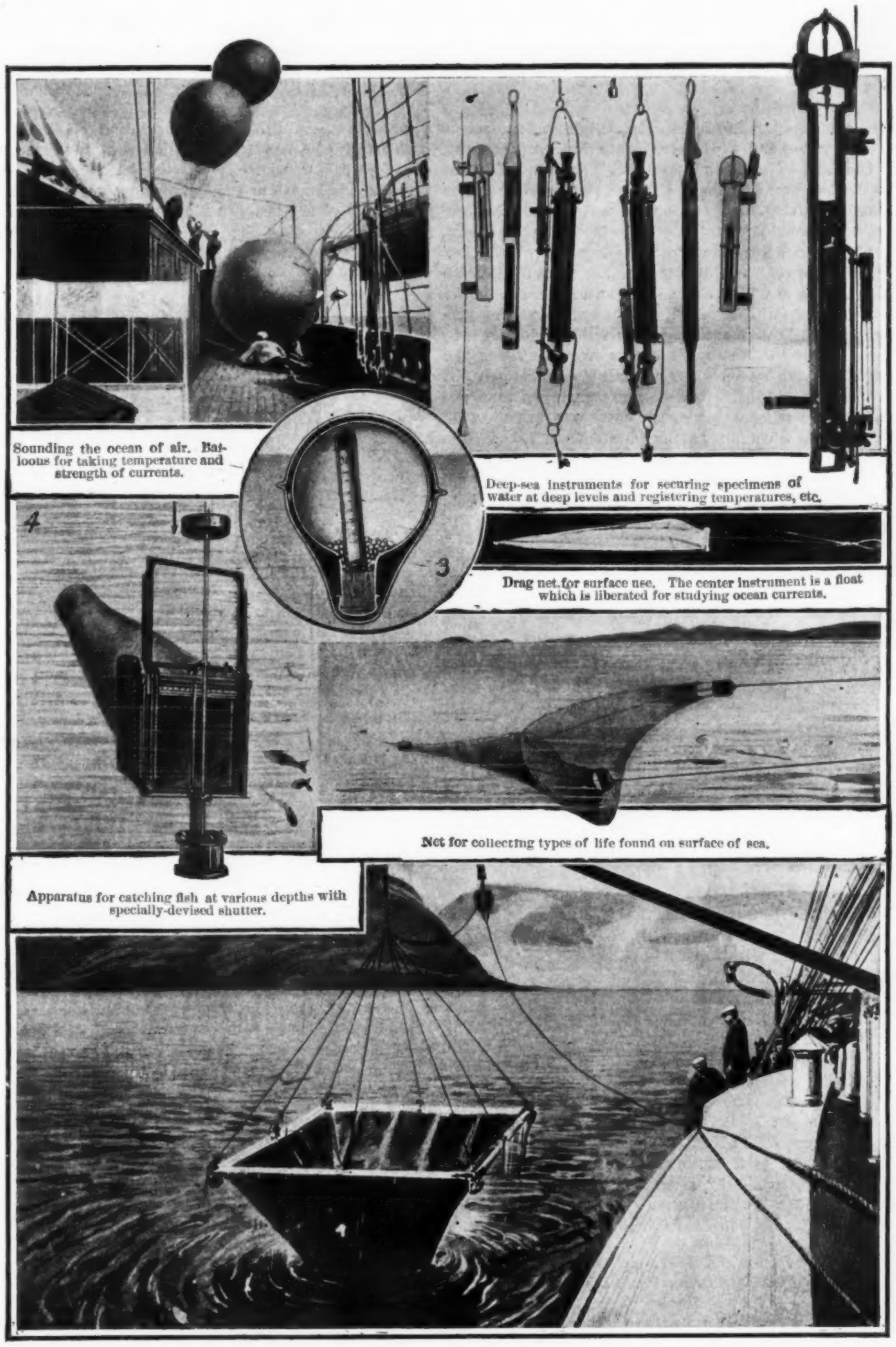
Caoutchouc is a collodial hydrocarbon which is found in the milky juice or latex of certain trees and shrubs. The latex is quite distinct from the ordinary sap of plants, and is contained chiefly in the middle layer of the bark, in a network of minute tubes, known as the lactiferous vessels. The caoutchouc proper is suspended in the latex in very small globules (about 0.00008 in. in diameter), which coagulate on heating and on treatment with chemicals; the coagulum consists of the hydrocarbon and of certain quantities of resinous and albuminoid substances whose proportions vary with locality and season. The colloidal nature of the rubber has rendered its study very difficult. It cannot be distilled in a vacuum without undergoing decomposition. When submitted to destructive distillation in a retort, various vapors pass over, of which those boiling between 30 deg. and 40 deg. C. (86 and 104 F.) (isoprene and other bodies), and between 160 deg. and 170 deg. C. (320 and 338 F.) (dipentene, etc.) have particularly been studied. A remarkable solvent for rubber was gained by Barnard at Greenwich in 1833, by heating rubber up to 315 deg. C. (599 F.) Continuing the important researches of Himly (Göttingen) and of Bouchardat (Paris), Greville Williams isolated, in 1860, isoprene, apparently of the formula $(C_5H_8)n$ and density of 0.68; and Bouchardat himself had observed that some distillation product of rubber changed into rubber when treated with hydrochloric acid in the cold. This product was the isoprene, which was henceforth regarded as being most closely related to caoutchouc, although it could only be obtained in small quantities from rubber.

This line of research—the study of the products of the destructive distillation of rubber and of cognate substances—was continued by O. Wallach, H. Euler (who determined the constitution of isoprene), Ipatieff, Emil Fischer, Harries, and others. Isoprene is defined as methyl divinyl, $CH_2=C.(CH_3).CH=CH_2$, and the constitution of the caoutchouc hydrocarbon itself is now supposed to be known. C. D. Harries, of Kiel, represents it as a double chain of hydrocarbon radicles, the two chains being held together by double bonds, so as to form a cyclic nucleus, and the caoutchouc hydrocarbon would thus be an unsaturated compound of the formula $C_{10}H_{16}$; that is, twice C_5H_8.

Most important for the technical development of the problem was, however, the observation made by Sir William Tilden in 1882 (then at Bristol, now in London), that isoprene could be obtained—again in small quantities—from terpenes (substances prepared from oil of turpentine), and that this isoprene (like the body obtained from the natural caoutchouc) underwent in the course of years a very slow polymerization into rubber; attempts to hasten the reaction resulted in the formation of dipentene and of other substances. The question whether the product was really caoutchouc, or a substance resembling caoutchouc, was at that time still more difficult to decide than it is at present, when characteristic reactions of caoutchouc with ozone, bromine, and nitrous acid are generally recognized. According to Harries, isoprene is ready to polymerize, but the resulting products are not really rubber, and exposure to the air merely thickens the liquid isoprene and yields an explosive peroxide. In a lecture recently delivered before the Oesterreichische Ingenieur and Architekten-Verein, Harries stated that he had, in seven years of experiments, been unable to confirm Tilden; he had found that isoprene remained unchanged when kept in contact with hydrochloric or organic acids for months. But as he himself claims to have effected the polymerization of isoprene into rubber, this criticism appears rather captious.

The chief point in Tilden's observation was that isoprene could be prepared from other materials than rubber—namely, by passing oil of turpentine through pipes at a red glow. Oil of turpentine is also the raw material from which the Elberfelder Farbenfabriken, vorm. Bayer & Co., start in their process which was worked out in their laboratories by Dr. Fritz Hofmann. The oil is converted into isoprene, and the isoprene treated with acetic acid. This acid transforms caoutchouc into a soluble compound; that circumstance suggested its use. Dr. A. Heinemann applies a process which has been worked or tried in London for more than a year. According to a British patent of 1907, he heats a mixture of acetylene and ethylene at dull red-heat, and converts the resulting divinyl into methyl divinyl, or isoprene, by the action of methyl chloride. The caoutchouc afterwards condensed from the isoprene is said to be equal to rubber. According to Harries' remarks on this process the three substances named, acetylene, ethylene, and methyl chloride, would simultaneously appear to be heated by being passed through hot-tubes, and would at once yield rubber by polymerization. Harries explained that he himself heated the very volatile isoprene (boiling point 37 deg. C., 98.6 F.) with acetic acid in a sealed tube, and that, at a temperature a little above 100 deg. C. (212 F.), a real rubber resulted. He added that the proper conditions had carefully to be observed, as otherwise smeary oils and resins were obtained. The formation of resins is, of course, not characteristic to these researches; they are the common trouble, and sometimes the despair, of the chemist who submits organic compounds to violent reactions.

Whether or not the tough, elastic, white or brownish products which these various workers claim to have obtained are really rubber, the time test can alone decide. Most rubber substitutes fail to pass that test, though they have their legitimate uses. Rubber substitutes are made from casein, vegetable albumen, gelatin and chrome-gelatin, glue, glycerin, oils, nitrocellulose, sugar, molasses, etc., in various combinations of these materials. If the rubber recovery from vulcanized waste had been successfully accomplished, the synthetical rubber preparation would not have become so important a problem. Isoprene can be reclaimed from some rubber waste; but Harries prefers the synthetically built-up isoprene for his experiments. One of the new raw materials now suggested, the oil of turpentine, is itself not an inexpensive substance. Turpentine is obtained from pine trees which occur in many countries, notably in Russia and the Southern United States. The mode of gaining the turpentine is still rather barbarous. In the United States the trees are "hacked"



Sounding the ocean of air. Balloons for taking temperature and strength of currents.

Deep-sea instruments for securing specimens of water at deep levels and registering temperatures, etc.

Drag net for surface use. The center instrument is a float which is liberated for studying ocean currents.

Net for collecting types of life found on surface of sea.

Apparatus for catching fish at various depths with specially-devised shutter.

SOME TYPES OF INSTRUMENTS USED BY MARINE BIOLOGISTS FOR EXAMINING SEA LIFE AND OCEAN TEMPERATURES.

The instruments shown here are used by the Prince of Monaco in his marine biological work. Those carried by the expedition are of a very similar character.

THE QUEST OF THE UNDISCOVERED SOUTH POLE.

once every week during the summer; after about ten years the trees become unproductive, and the "lightwood" left—the lower portion of the tree, which, being saturated with resins, is by no means "light"—is distilled with saturated steam or superheated steam in order to extract its turpentine. There were about eighty such turpentine works in the United States a few years ago, and the methods employed were as much in need of improvement as the crude ways in which rubber is still gained in many districts.

Another of the new materials—acetylene—is cheap enough. It is obtained from calcium carbide, and artificial-rubber works might afford that aid to the calcium carbide industry of which it stands much in need. There is a further side to this question, moreover. Acetylene (C_2H_2) is an unsaturated hydrocarbon, which, though ready to combine with other elements, is not easily induced to build up complex molecules containing many carbon atoms, such as are supposed to exist in caoutchouc. Acetylene readily takes up chlorine, however, and the chlorine can be substituted by hydrocarbon radicles. This problem is occupying several chemists both in this country and abroad, and even if the synthetical preparation of caoutchouc should not yet prove a commercial success, these researches promise to open up new fields of chemical industry.—Engineering.

LIGHT AND ELECTROMAGNETISM.*

ELECTRIC WAVES AND THE ELECTROMAGNETIC THEORY OF LIGHT.

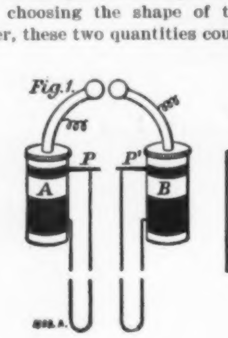
Continued from Supplement No. 1806, Page 111.

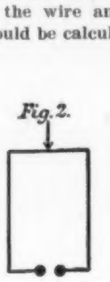
In commencing his fourth lecture on the subject of electric waves and the electro-magnetic theory of light, at the Royal Institution, Sir J. J. Thomson said that on the last occasion he had shown that electric waves actually existed, and in the present lecture he proposed to consider various methods which had been employed to determine the velocity with which they were propagated, and to see whether such an investigation gave any clue as to their nature. Most of the experiments on the velocity of propagation, he proceeded, had been made on waves guided along wires, though, perhaps, the most interesting point was the velocity of the waves when passing freely through air, and not so guided. It was, however, easy to prove that the velocity was in both cases the same. This fact had been established by Sarasin and De la Rive at a very early stage of their researches. On a previous occasion he had himself, Prof. Thomson continued, shown in that room that interference effects could be obtained in two ways. In the one case the wave passed only through the air, and, using a particular resonator, it was possible to find the distance in such cases between two positions of resonance. In the second case the waves were guided between wires, and he had shown that analogous effects were then produced. He had further pointed out that the position of resonance was such that the time taken for the wave to travel to the point of reflection and back was equal to the period of the detector used. Hence using the same detector for the case in which the waves were reflected from a screen, and for that in which they were guided along wires, it followed that if the distance of the position of resonance from the point of reflection were the same in both cases, the time taken must also be the same, since this was the period of the detector. The comparison had been carefully made by Sarasin and De la Rive, who found that the distance of the detector from the screen in the one case and from the end of the wire in the other was exactly the same. It followed, therefore, that experiment coincided with theory in showing that the velocity of the wave when guided was the same as it was when freely passing through space.

Coming to the question of actual experimental determinations of the velocity of these waves, he would, the lecturer said, begin by describing the only one in which this velocity had been determined by direct observation. The experiment in question was made by Blondlot about fifteen years ago, the apparatus used being represented in Fig. 1. It consisted of two Leyden jar *A* and *B*, each having its outer coating in two separate portions—viz., a narrow ring of tin-foil near the top, and a broad ring near the bottom of the jar. A bad conductor was used to connect the narrow ring with the broad one. From each narrow ring a short pin projected as indicated at *P*, *P*[1]. From each broad ring a long wire, many meters in length, extended as indicated in the figure, terminating finally in the corresponding short pin *P* or *P*[1]. The apparatus was, Professor Thomson said, based on the theory that on the discharge of the jar there would be a little spark between the two points *P* and *P*[1], due to the discharge of the narrow rings of tin-foil from which each projected, and that this would be followed by another spark due to a disturbance traveling along the long wires. The actual process of discharge was observed in a revolving mirror, and, from the known speed of rotation of this, the interval between the two sparks could be calculated, and this was assumed to be the time taken for the electric wave to travel along the wire. The result obtained was that, within the limits of the errors of the experiment, the velocity of these waves was equal to the velocity of light.

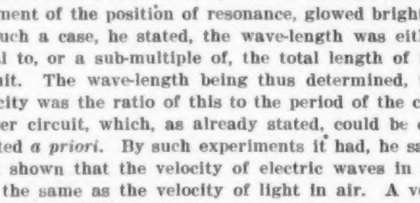
This, Prof. Thomson continued, was the only direct measurement which had been made of this velocity. The most accurate methods of measurement were, however, indirect, being based on certain theories, which were, however, so well established as to be used with confidence.

In a previous lecture of the present course he had alluded to Lord Kelvin's calculation of the time of vibration of a Leyden jar, which was, he proved, equal to $2 \pi \sqrt{L C}$, where L was the self-induction depending on the length and shape of the wire, and C was the capacity of the jar. The important point was that, by suitably choosing the shape of the wire and of the condenser, these two quantities could be calculated, and





an exciting circuit, the period of which was known, could thus be obtained. If, then, the length of the wave could be determined by other means, the velocity v could be calculated from the expression $\lambda = v$ T where λ was the wave-length and T the time of one vibration. The wave-length λ could be found by making use of the principle of resonance. To show this, Prof. Thomson had arranged an exciter and a resonating circuit, the latter consisting of a loop of wire which could be completed by a movable bridge, so as to form a closed circuit. By moving the bridge, a position was found in which a neon tube, used to indicate the attainment of the position of resonance, glowed brightly. In such a case, he stated, the wave-length was either equal to, or a sub-multiple of, the total length of the circuit. The wave-length being thus determined, the velocity was the ratio of this to the period of the condenser circuit, which, as already stated, could be calculated *a priori*. By such experiments it had, he said, been shown that the velocity of electric waves in air was the same as the velocity of light in air. A very interesting question then arose, since, as was well known, light moved more slowly in such substances as glass and water than in air. The ratio of the velocity in these substances to that in air was known, and the point to be determined was whether,



if electric waves were also sent through such substances, the velocity would be equal to that of light in the same bodies.

At a very early stage of research into this question he had himself, Sir Joseph continued, used a rough method of finding the velocity of electric waves through paraffin wax and sulphur. The arrangement used was the simplest of any in theory, though it was surpassed by others in the accuracy of the results obtained. The apparatus used, Fig. 2, consisted of a rectangle of wire having a spark-gap at the middle of its lower arm. At the top it was connected by a sliding contact to a source of electric disturbances. When this wire was in the center of the upper arm the apparatus was symmetrical, and there was no tendency for sparks to cross the gap, since both balls were at any instant at the same potential. On shifting the contact, however, so as to make the length of conductor between it and the ball shorter on one side than the other, sparks were observed to pass. This was also the case if, with the contact in the central position, one arm of the apparatus was immersed in oil. It was easy to see that the method could be used to find the ratio of the velocity of the wave in air and in oil by making the extent of the immersion adjustable and shifting the contact till the sparks disappeared. In this way it was possible to get a rough measure of the relative speed of the electric waves in different substances. In a reproduction of the experiment shown by Professor Thomson a very sensitive neon tube was used to replace the spark-gap, and this tube lit up brilliantly when one arm of the apparatus was immersed in paraffin. His own original experiments, the lecturer continued, had proved that in the case of paraffin wax the ratio of the velocity of the wave in air to that in wax was much the same as the corresponding ratio for light waves. Much more accurate methods of comparison were now available, one of the best being due to Drude, of which he had in that room a replica. It consisted (see Fig. 3) of a wire bent, as secondary, round an exciting circuit at *Q*, while the free ends, after passing through the air, dipped into a tank at *R*, as shown. The exciting circuit consisted of two semi-circles, each having a ball terminal, as indicated, these balls being connected to a coil. The exciting circuit was itself immersed in oil, so as to require a higher potential for the production of a spark, and thus to obtain a more vigorous disturbance. Movable bridge-pieces *E* and *F* were arranged across the free ends of the wire, and the experiment consisted in finding positions for these bridges at which resonance was established. The principle on which the apparatus was based was much the same as that governing the resonance of a column of air in a tube, over the open mouth of which a vibrating tuning-fork was held. Making use of a long vertical tube containing water, the length of air column acted on could be adjusted by raising or lowering the level of the water. Starting with the water near the top and then gradually lowering its level, a position would be found at which the tube began to "sing out." If the level were still further reduced, the effect disappeared until a certain other level was reached, when the tube would again respond. The distance between the two levels was half the wave-length in air of the note sounded by the tuning-fork. The two wires with the bridges in Drude's experiment corresponded to the water column of adjustable height, and Professor Thomson showed that with the "air" bridge in one position resonance was obtained, as indicated, by a neon tube. On shifting the bridge the brightness of this tube died away, but it became luminous again when the bridge reached a certain distance from the first point of resonance. This distance, Professor Thomson said, was half the length of the electric wave in air. Repeating the experiment, moving this time a bridge over that portion of the wires immersed in paraffin, he showed that the wave-length was shorter than in air, so that the wave took a longer time to pass through the paraffin than through the air, and the ratio of the two was, he said, the same as in the case of light waves. With the wires immersed in certain other substances, however, this was no longer the case. Thus, taking the velocity of light in water as 1, that in air was from 1.3 to 1.4, the ratio being thus rather more than half. In the case of electric waves, however, the experiment being tried in normal conditions, the ratio came out as one-ninth, hence, while the electric and light waves had the same velocity in air, their velocities in water were entirely different. Substances which showed this great difference in the speed of electric and light waves all had a certain peculiarity in their chemical constitution. Of them water was the most conspicuous example, but the effect was also shown by alcohol and by glycerine. All these were characterized by chemical-formulæ containing the radicle O^2H, which, seemed therefore to be associated with this great difference in the velocity of electric and light waves. Sir James Dewar and Professor Fleming had, however, found out that if the temperature of water, or rather ice, was reduced to that of liquid air, this excessive slowness of the electric waves disappeared, so that

* From Engineering.

these waves went through very cold ice at much the same speed as light; this was also the case with alcohol and glycerine, so that it was possible to, as it were, freeze out the peculiarity in question, provided the temperature was sufficiently low.

It might be thought, he proceeded, that the peculiarity in question arose not from the chemical consitution of these bodies, but from the fact that they were not good insulators. If, however, the experiment were repeated after adding a little acid to the water, so as to increase its conductivity many hundred times, the wave-length at normal temperatures was still the same, as in the case of the very purest water with the very lowest conductivity. As stated, however, at the temperature of liquid air the abnormality disappeared, and water fell into line with such substances as paraffin, the velocity of the electric wave being the same as that of light. This was proved by Dewar and Fleming, who found that at —200 deg. C. (—328 deg. F.) glycerine had a dielectric constant of about 3, while at ordinary temperatures the figure was 18 or 19. The square of the dielectric constant was, the lecturer said, equal to the ratio of the speed of the electric wave in air to its speed in the body under examination. The value for water came down to 2.4 in place of the 81 found at ordinary temperatures. It appeared that whatever caused the anomaly could be frozen out. The subject was a very interesting one, since the waves affected were several meters long, and had times of vibration of quite a different order from those associated with ordinary molecules. Water, in short, showed anomalous dispersion, refracting these long waves more than it did short ones, which normally were bent the most. In all theories as to anomalous dispersion the phenomena was associated with the existence of periods of vibration among the molecules comparable with the period of the light affected. It would seem, therefore, that in water something was showing a time of vibration millions of times that usually associated with molecules, so that apparently some complex substance was formed which ceased to exist at low temperatures, and that we had to deal with great clusters of molecules rather than ordinary molecules, and these gave rise to the excessive retardation of the electric waves. The periodicity observed would indicate that these clusters were very complex indeed, for the length of the electric waves was several meters.

It appeared conceivable, the lecturer continued, that the peculiarity in question might throw light on the possible existence of complex aggregates in bodies, often thought to be quite simple in construction. These aggregates continued to exist until the temperature was lowered to between —150 deg. and —200 deg. C. (—238 deg. and —328 deg. F.) Other substances such as ethylene di-bromide, Sir Joseph continued, showed hardly any temperature change in the value of the dielectric constant. This was typical of many substances, including paraffin, but there was another set of bodies constituting a second type, in which the change with the temperature was large. Summing up, then, the velocity of electric waves in air was the same as that of light, and this was also the case with a large class of media. Other bodies, however, existed in which, in normal conditions, the speed was very much less than that of light; but these could be brought into line with the foregoing by sufficiently reducing the temperature. There was thus a very strong probability that there was no real difference between waves of light and electric waves, and this he proposed to discuss in his next lecture.

(To be continued.)

THE ART OF DISCOVERY.*

MAKING DISCOVERIES BY RULE.

BY WILHELM OSTWALD.

When Schiller sent the first draft of his "Buergschaft" ("Security") to Goethe for criticism, he wrote: "I am curious to know whether I have been fortunate enough to discover all of the important motives which can be found in this subject. See if anything else occurs to you. This is one of the cases in which one can proceed in a definite manner and almost make discoveries by rule." These last words show how Schiller was struck by the possibility of making discoveries in accordance with definite technical rules, although such a process suggested itself to him. The general view is still very similar to Schiller's, and discovery by rule, either in poetical or technical works, seems like a contradiction in terms. We are accustomed to regard discoveries as something which cannot be commanded, but depend upon favorable opportunity.

This rather mystical view is opposed to the sober and sordid fact that discovery has already been organized extensively on a commercial basis. I shall not describe how Edison, after developing his great discoveries, was "capitalized" by a company with the expressed object not only of exploiting the discoveries already made, but also of making other discoveries of equal importance. In the great industries, the machine shops, the electro-technical establishments, and especially in the chemical factories, we find laboratories of discovery in regular operation. The cool, calculating business heads of these establishments evidently find that the great outlay involved in these laboratories is judiciously expended, for they would immediately strike out the appropriations for this purpose if they found the laboratories unprofitable.

It is possible to regard these laboratories as a means of systematically making use of the chances of discovery. Priestley, who at the end of the eighteenth century enriched chemistry with so many discoveries, likened his method to that of a huntsman who goes into the fields and forests, not knowing what he shall find, or whether he shall find anything. It is a well-known fact, however, that hunting is now carried on in a more systematic manner. For the amusement of royal personages, in particular, it has been found possible to eliminate chance and to replace it by certainty. We are now treading a similar royal road to discovery. Instead of strolling through the field and relying upon chance, we have organized a regular drive, so that only a poor shot can fail to bring down the game.

This improvement in the art of hunting evidently consists in the replacement of the chance movements of the individual hunter, who can only cover a small part of the field, by a complete covering of the field with huntsmen and stalkers. In other words, no possibility of escape is left to the game. The modern art of invention and discovery is based upon the same principle. It covers the entire field of possibilities with a systematic drive, so that no facts can escape discovery unless the huntsmen are poor shots. I will now leave metaphors and turn to fact. If I speak more of scientific than of technical discoveries, this is because I have more exact knowledge of the former than of the latter. From personal experience in both fields, I am convinced that they may be regarded as essentially identical for our purpose. As an example, I select an early research of the celebrated botanist, W. Pfeffer, concerning the swarm-spores of certain algæ. The male flowers of these plants produce spores which move spontaneously through the water and reach the female flowers with perfect certainty. Pfeffer asked himself whether these movements might not be caused by some substance produced by the female flowers. He expressed the sap from a number of female flowers, placed it in a glass tube, and found that the swarm-spores directed their course as eagerly and accurately to the glass tube as to the female flowers. Thus, his question was answered in the affirmative, but now arose a second question—what substance causes this effect? The prospect of answering this question by direct chemical analysis of the flowers was hopeless, as the flowers contained hundreds of diverse organic compounds which the ablest chemist could not have isolated and identified. It was, therefore, necessary to attack the problem from the other side and to study the attraction exerted upon the swarm-spores by known substances; but this would have required many thousands of experiments with as many known organic compounds, and would have occupied a very long time. Pfeffer, therefore, treated the problem comprehensively by simply mixing together all of the substances on the top shelf of his cabinet and testing the effects of the mixture upon the swarm-spores. He proceeded in the same manner with the contents of the other shelves, until he found a mixture which attracted the spores. If we assume that there were 100 substances in this mixture, he had found that the attraction was due to one of these 100 substances. Pfeffer next divided the whole number into the fifty on the right half of the shelf and the fifty on the left half, and thus limited the field to fifty substances by means of only two experiments. The group of fifty was similarly subdivided, again and again, until the substance which attracts the swarm-spores was isolated. It proved to be malic acid.

This is the whole secret of the art of discovery. The entire field of possibilities is divided into sections which can be controlled by the means at our command and each section is separately examined. By this method the particular part of the field which contains the solution of the problem cannot escape discovery.

It may possibly be objected that it is necessary to have a thorough knowledge of the subject in order to carry out this systematic subdivision of the field of possibilities, but the example quoted above shows that any method of subdivision which covers the whole field may be used. What is more superficial than the classification of chemical substances according to the shelves on which they happen to stand in a cabinet? Yet this apparently ludicrous method resulted in the solution of a very subtle problem.

If we prefer, we can express the process in learned language. Let us designate by a, b, c, d, etc., the various factors or circumstances which are concerned in the phenomenon under investigation. If we designate this phenomenon by E, the relation between it and its factors can be expressed by the general equation of $E = f\ (a,\ b,\ c,\ d,\ \text{etc.})$, which expresses the fact that the phenomenon E is a function of a, b, c, d, etc. In order to discover the mode of action of these factors, the most certain method consists in varying one or a number of them and leaving the others unchanged. The observed changes in the phenomenon must depend upon the factors which have been changed, and in this way their method of action can be studied. When a has been eliminated as ineffective the process is repeated with b, and so on, until the effective factors are found. Then the entire phenomenon is within our grasp, and it becomes possible to plan a successful research. I am quite certain that the objection will be made that no inventions or discoveries are made in this mechanical fashion, but that genius unconsciously and instantly grasps the correct solution. This belief is only a tradition, and a very mischievous one. In every case in which we have personal descriptions of the labors of great men, we find that these men have worked as strenuously as any of us common mortals and with far greater devotion. The four notes which open Beethoven's Fifth Symphony, representing Fate knocking at the door, were developed step by step to their imposing simplicity, as we learn from the master's sketch books. Every master, in every field of endeavor, has become a master, not by stopping work earlier than others, but by keeping at it longer, and finding the possibility of improvement where others would have been content with the result already accomplished.

This tradition is mischievous because it induces the novice to rely upon fortunate chance. I have had abundant opportunity of observing this infantile disease in young investigators whom I have guided in their first steps in the path of discovery. When the systematic method, by which the problem could be gradually driven in and grasped, had been explained to them, they could seldom resist the temptation of seizing instantly upon some one of the countless possibilities, with the secret hope that they had "instinctively" found the right solution; for every enthusiastic beginner entertains the modest hope of being a genius. The uniform result was disillusionment and waste of time, for the systematic method not only assures success, but is also, on the whole, the most economical of time and energy, as any one familiar with the theory of probabilities can easily calculate.

There is, it is true, a scientific instinct, i. e., an unconscious trend of thought which leads to the selection, from many possibilities, of one suited to the purpose; but, as biologists regard every instinct as the result of a long process of natural selection, so the scientific instinct is developed, from long experience, in the latter part of the investigator's career. Then he can greatly shorten the process, but not without incurring the danger of one-sidedness.

Is it possible, then, for every man to become a successful discoverer by following the rules? the in-

* Translated from an essay in Ostwald's recent collection of miscellaneous writings, "Die Forderung des Tages."

credulous reader asks. No; no more than it is possible for every man to become a good violinist, or an expert mechanician. In order that this plan can be followed with success a sufficient endowment of imagination and of positive knowledge must be present.

The former facilitates the planning of the hunt, the latter does the work of the beaters and drives the game from its hiding places. But although it is not possible for every one to master the art of discovery, the art can still be learned. I have been convinced of this, to my consternation, in my own household. I am accustomed, at dinner, to submit to my boys various little technical problems, asking them to see what they can make of them. The boys learned the art of discovery so quickly, that at times I have been fairly overwhelmed by their achievements.

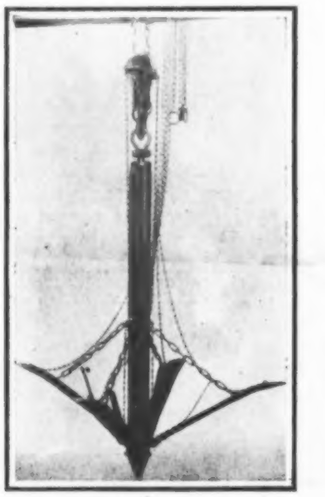
The art of discovery resembles all other arts and accomplishments. At first the prerogative of a few independent minds, the arts subsequently were acquired by pupils and imitators, although at first in a very imperfect manner. Then they gradually became common property, until finally some of them, like reading and writing, became a part of the intellectual inventory of every one.

We have seen this development with our own eyes in the case of bicycling, and we are approaching a similar phase in the arts of discovery and invention. But although the general state of culture exhibits this progressive improvement, there will always be differences in the readiness with which individuals are able to utilize the common possession. On the other hand, it is in the nature of all such developments to diminish these differences, as the history of civilization abundantly proves.

AN ANCHOR FOR AIRSHIPS.

AN UMBRELLA-LIKE FOLDING ANCHOR.

The disaster which befell the Zeppelin airship at Uechterdingen has led Captain Fuchs to design an anchor for airships. The use of this anchor is very simple, and it affords perfect security, except on rocky ground, and gives great resistance to a vertical pull. As the accompanying illustrations show, the anchor is composed of a shaft and four arms, attached to the shaft by joints, so that the whole contrivance can be open and shut like an umbrella. Before the anchor can be used it is necessary to bore in the ground a hole from 6 to 10 feet deep, which operation can be accomplished with a good drill in 5 or 10 minutes. The anchor in its closed condition is then lowered into the hole until it strikes the bottom. The pull of the cable attaching the anchor to the balloon causes the arms to unfold and their prongs to take hold upon the earth. An anchor weighing 125 pounds penetrates into the earth for about 6 feet around the hole and embraces a mass of earth weighing from 5 to 10 tons, according to the character of the ground. This resistance can be increased indefinitely by increasing the dimensions of the anchor.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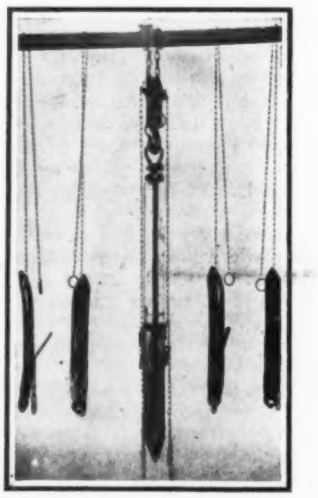
CLOSED.


DISMEMBERED FOR WITHDRAWAL FROM THE GROUND.

The practical utility of the anchor would be very doubtful if it were necessary to abandon it, or to dig it out of the ground, after use. It is so constructed, however, that, by drawing a number of bolts, the arms can be detached from the shaft while the anchor is buried. The parts can then be drawn out of the earth separately, and reassembled for future use. The entire operation can be performed in from 1 to 3 minutes.

This method of anchoring an airship offers the great advantage that the vessel is fastened only at the bow and can turn round the anchor, floating always with its longest dimension parallel to the wind.

This anchor can be used also for other purposes, for example, for anchoring nautical vessels in shallow water, in which it can be rammed into the ground, and in anchoring buoys, in which case it dispenses with the use of costly anchor plates. It may also prove useful for securing large tents, wheeled chairs and other vehicles, scaffolding, captive balloons, trees which are to be felled, etc.—Umschau.

PRESERVING FISH IN PAPER.

Capt. A. Solling, Danish fisheries agent in London, has for some time been experimenting with the packing of fresh fish in specially prepared paper, and has reported interesting results, which Consul-General Wallace C. Bond, of Copenhagen, reviews:

The main point in the preservation appears to be to inclose the fish as free from bacteria as possible in some cheap and convenient material which will keep out the air and prevent the intrusion of injurious aerial bacteria. Another important feature of fish preservation is to prevent the ice water, with its injurious bacteria, from contaminating the fish, and at the same time to apply the frigidity of the ice in order to prevent the development of the bacteria that might be already in the fish.

By the Solling method of packing the fish in the paper before placing them on the crushed ice, the air is excluded and the ice water is prevented from reaching the fish. The effect of the ice through the paper prevents the development of any bacteria that might be already in the fish. In order to attain this result it is absolutely necessary that the fish be treated while alive, or at least when quite fresh, and it is therefore better to undertake the treatment on board the fishing boats.

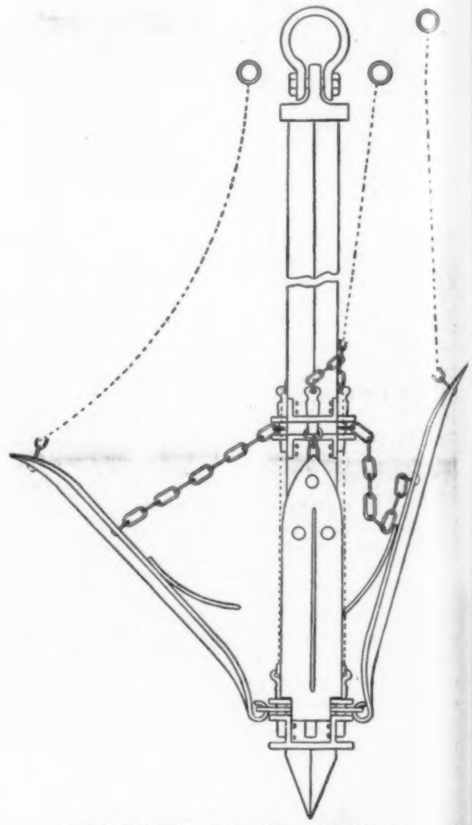
The fish should be cut while it is yet alive, the insides removed and the gills cut away; the head, however, ought always to be left. The sound, where such is found, is cut through, lengthwise, and all the blood under it is removed. The fish must be cut so far back that all the blood accumulated at the anus can easily be removed. The fish is then cleaned and scrubbed well in salt water, inside as well as out, with a stiff brush until all the blood stains are removed.

As soon as the fish has lain long enough for all the blood to run off (it must be carefully observed that no bloody water remains in the belly), the fish is packed in the paper, which must be square in order to obtain the best packing, and each side at least one and one-half times the length of the fish.

To start with, the fish is placed crosswise at one corner of the paper, and wrapped up firmly. The two corners are bent in and wrapped up, and the fourth corner tied with a piece of cord. The objection may be raised that this way of treating fish is too particular and takes too long, but the increased work and the increased expense will soon be offset by the higher price secured on account of the better preservation of the fish, and the intelligent fishmonger will soon discover the advantage of handling fish which, if not sold to-day, may be sold in 3, 4 or 8 days and still be equally good and fresh.

It is not yet proved that all kinds of fish are equally adapted to packing in this manner; it may not pay, either, to pack all kinds of fish, but the better kinds of fish, like sole, turbot, kitt, halibut, cod, plaice, and haddock, would bring better prices if treated in this way. Fresh-water fish like salmon, carps, and zanders, which are to be transported in a few days, would have a different appearance at the end of the journey if packed in the paper.

The main point is that the fish must be cut, the bowels and the gills removed, and the fish well cleaned if it is to be sent long distances. From various experiments it is claimed that fish packed according to this method will keep fresh for a long time and make a far healthier and better product than when kept in direct touch with the ice. The paper is manufactured in England.


THE FUCHS AIRSHIP ANCHOR.

According to the Electrical World six resistance thermometers will be embedded in the walls of the locks at Gatun, Panama Canal, in order to determine the degree of heat attained at various stages of the hardening of the concrete. By this means data will be obtained in relation to the heat produced by the chemical changes coincident with the hardening of the concrete. The thermometer consists of three parts—a resistance bulb, wires connecting the bulb with an indicating instrument and the indicating instrument itself. The resistance-bulb is an iron cup in which is inserted a coil of wire by means of which the temperature is determined. This bulb is embedded in the concrete at any point desired, and two lead-sheathed copper wires connect it with the indicating instrument. The resistance of the circuit is determined at the time of installation and the corrections remain practically constant. Any number of bulbs may be connected with a single indicating instrument, but at Gatun provision is made for eight bulbs. The indicating instrument and the switches connected with it are mounted on a marble slab, the set being a portable one. By closing the circuit of any thermometer by a push-button switch, the resistance is measured and the instrument records it in terms of temperature. A small storage battery furnishes the electrical energy. The readings from these thermometers will be plotted, and in this way a complete graphical record of the varying temperature of the concrete will be kept.

THE MOON IN ULTRA-VIOLET LIGHT.*

A PECULIAR DEPOSIT DISCOVERED ON THE LUNAR SURFACE.

BY R. W. WOOD.

The Moon has been so carefully scrutinized and so repeatedly photographed that it seems at first sight as if very few additions to our present knowledge of her surface are to be expected. In the present paper I shall point out a method which promises to yield very fruitful results, a method which has already resulted in the discovery of a vast deposit of some material quite different in composition from the rest of the lunar surface around one of the craters, and which may even enable us to learn something of the nature of the materials composing the surface.

During the past summer at my laboratory at East Hampton, Long Island, I have been engaged in the study of the appearance of things photographed by

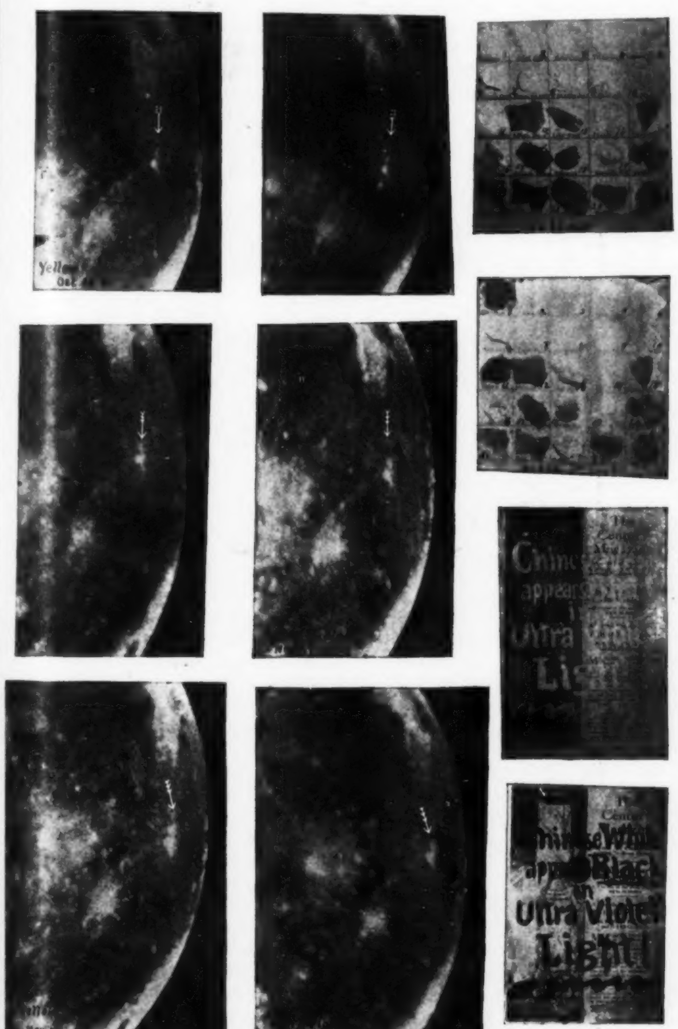


Fig. 1.—ULTRA-VIOLET LIGHT PHOTOGRAPHS.

Fig. 2.—LUNAR PHOTOGRAPHIC TELESCOPE.

infra-red and ultra-violet light. In fixing up my laboratory I have been aided by a grant from the Elizabeth Thomson fund, and the experiments about to be described were paid for out of this grant.

The infra-red photographs were made with a screen which transmitted only the region of the spectrum above 7,000, on Cramer Spectrum plates, which I found superior to any other commercial plate in this region of the spectrum. The radiations by which the image was formed fell within the range $\lambda = 7{,}000 - 7{,}800$. While this region is not, strictly speaking, wholly invisible, still its action upon the retina is so weak in comparison to that of the rest of the visible spectrum, that it plays no part in ordinary vision, and I feel justified in speaking of it as infra-red. The screen consisted of a sheet of very dense cobalt glass, ground and polished, combined with a very strong solution of bichromate of potash, or a gelatine film stained with one of the red aniline dyes. The pictures, especially those of sunlit landscapes, were most unusual and very interesting, for the sky came out jet black and the trees and grass as white as snow. They were, however, of little scientific value, and the reader is referred to a forthcoming number of the Century Magazine for a fuller account of them. I have not yet attempted to photograph the Moon in infra-red light, though the experiment is one that should most certainly be made, in view of the facts brought out by the work with ultra-violet light.

These ultra-violet pictures were made with a range of the spectrum to which glass is impervious, namely, that transmitted most freely by a silver film, ($\lambda = 3{,}000 - 3{,}250$). It was necessary, therefore, to use a lens of quartz heavily silvered on one surface. The silver film was of such a thickness that a window, backed by a brightly lighted sky, was just barely visible through it. Pictures made with this combination were made by rays to which glass is opaque, and the introduction of a thin sheet of clear window glass in front of the lens effectually stopped all photographic action, the time of exposure being the same in the two cases.

Photographs of landscapes made by the ultra-violet do not differ very greatly from ordinary photographs except in the curious circumstances that objects standing in full sunlight cast no shadows. The ultra-violet light comes almost entirely from the sky, the illumination being not unlike that which obtains in a fog. A number of interesting pictures made in this way will be found in the article already alluded to. A description of them in the present paper would be out of place. It was found in the course of the experiments that many substances, white in ordinary light, were quite black when photographed by the ultra-violet rays. This was true of white garden flowers, and in an especially marked degree in the case of Chinese white paint (zinc oxide). On Fig. 1 will be found reproduced two photographs of the page of a magazine on which are painted some words with this pigment. The upper picture was made with an ordinary lens of glass, the lower with the quartz-silver combination. It will be observed that in ultra-violet light the Chinese white is much blacker than the printer's ink.

While painting the words, I inadvertently omitted one letter in the word "appears." The mistake was rectified by carefully erasing the last three letters with a brush and clean water, drying the paper and painting the letters anew. So far as I could see I removed every trace of the white pigment, and no trace of the correction appears in the photograph made by visible light. The one made by ultra-violet, however, shows a very conspicuous smutch, which shows us how sensitive these rays may be in detecting slight traces of substances which absorb them. These two pictures are given to illustrate the principle of the method as applied to selenography, and it is clear that a slight but extensive deposit of zinc oxide on the Moon's surface which was quite invisible and which could not be photographed by ordinary means, might be clearly brought out in a photograph taken through a silver film with a quartz lens.

The first experiments in lunar photography were made with a quartz plano-convex lens of a little less than 2 meters (6.56 feet) focal length. The lens was made so that its focal length for the ultra-violet rays utilized should be as nearly as possible the same as that of my 12 centimeter-refractor (4.72 inches) for yellow light. My plan was to superpose a negative made by ultra-violet and a positive made by yellow light. Uniform density would then result except at spots differentiated by the two sorts of rays utilized. This will be recognized as an adoption of the principle used by Prof. Pickering for detecting variable stars.

It was found that with a silver film of the requisite density, an exposure of about two minutes was necessary. This necessitated an arrangement for pretty accurate following, and as I had no clock driven telescope I improvised an equatorial mounting for the telescope out of an old bicycle frame. The wheels were removed and the frame stood up in a wooden box in such a position that the steering axis pointed at approximately the latitude angle of East Hampton. The box was then filled with Portland cement which was allowed to solidfy. The box was then knocked to pieces, and the frame was left imbedded in a massive block of artificial stone. This was mounted on a small brick pier and one end blocked up until the steering axis pointed at the pole. The twin telescopes were mounted on a declination axis fastened to a piece of wooden joist attached to the handle bars. Slow motion was communicated by means of a brass screw of small pitch, supported on a rod attached to the T-tube which originally held the saddle, and the telescope was elevated or depressed by an iron rod, clamped to the end of the saddle which carried the telescopes, and passed down through a block of wood attached to the front forks. A fuller description of the arrangement will be found in the Scientific American for October 23rd, 1909, and in a recent number of the English Mechanic.

Cramer Isochromatic plates were used. Exposures were made with the quartz telescope using the other telescope with its cross hairs as a guiding telescope, and also with the visual telescope through a bichromate

* Popular Astronomy.

of potash screen. In the latter case the time of exposure was less than half a second and no attempt was made to follow.

The plates were developed in hydrochinon, and a very large number were exposed with different times of exposure and different lengths of development. It was found that the plates made with the ultra-violet screen showed much less contrast, and on all there is a trace of an area bordering the crater Aristarchus which is dark in only ultra-violet light. The size of the image was too small, however, to make the results very satisfactory, and having demonstrated the feasibility of the method, the experiments were discontinued until my return to Baltimore. Early in October I assembled apparatus for obtaining pictures on a larger scale. It seemed better to use a reflector rather than a quartz lens of longer focus for obvious reasons. A silver on glass instrument would not be very efficient, since silver reflects only about four per cent of the rays with which we are concerned.

A 15 centimeter (5.91 inch) concave mirror of speculum metal about 3.5 meters (11.48 feet) focus was mounted at the eye end of the ten-inch refractor of the University, and the plate holder fastened to the other end of the tube near the object glass. The plate was 7 centimeters (2.76 inches) to one side of the axis of the mirror, but the definition was nearly perfect. The long focus quartz lens with its silvered film was mounted about 5 centimeters (1.97 inches) in front of the plate to serve as a ray filter.

Photographs taken with this apparatus showed clearly the existence of an extensive deposit to one side of Aristarchus which did not appear in any of the pictures made with the yellow screen. The deposit is shaped much like a figure 3. Three pairs of the photographs are reproduced on Fig. 1, taken on three different dates. As is clear from these pictures little or no trace of the deposit is shown by yellow light. I have tried photographing it with a nitroso screen, which transmits a region of ultra-violet slightly less refrangible ($\lambda = 3{,}400 - 3{,}700$) than that passed by the silver film, and find that this deposit appears, but that it is not nearly as distinct as with the shorter radiations.

In the case of the pictures made in Baltimore I find that the contrast between the gray plains and the bright areas is about the same in the two cases, and I am at a loss for an explanation of this, for with the East Hampton apparatus this was never the case.

The fact that the bright craters are quite as bright with the ultra-violet light enables us at once to say what the strongly reflecting materials is *not*, for I have found out that zinc oxide sulphur and certain other light colored substances are quite black in ultra-violet light. As to the nature of the dark deposit around Aristarchus further experiments will be necessary before we can begin to guess. By a process of elimination we shall doubtless be able to exclude a large number of substances, narrowing the thing down still further by measuring its reflecting power for different regions of the ultra-violet and visible spectrum. Infrared pictures will also help in all probability. I have already commenced the study of various materials, igneous rocks and volcanic ejecta. The substances are laid out on a paper checker-board and photographed in different regions of the spectrum, by using ray filters. Two of these pictures are reproduced on Fig. 1, the upper taken by yellow, the lower by ultra-violet light. No. 1 is precipitated sulphur, almost white in visible light, black in ultra-violet, and all the other substances are given in the following table:

1, Sulphur; 2, zinc sulphate; 3, kaolin; 4, talc; 5, arsenic; 6, sodium carb.; 7, powdered glass; 8, calcium sulphite; 9, calcium carbonate; 10, lead acetate; 11, zinc oxide; 12, shale; 13, limestone; 14, chalk; 15, trachyte; 16, clay; 17, granite; 18, rhyolite; 19 powdered quartz; 20, granite; 21, pitchstone; 22, felsite; 23, volcanic tuff; 24, volcanic tuff; 25, augite.

Specimens 23 and 24 are worthy of especial notice, since, they appear alike in yellow light, while in ultra-violet one is very much darker than the other.

On looking over photographs of the Moon taken at various observatories I find that the Aristarchus "black desert" is much more distinct in the pictures made on ordinary plates than on the Iso plate with a yellow screen. With my small mirror, however, I get very little trace of it except when I employ the quartz-silver filter.

It seems probable that photographs made on a larger scale will show other deposits of this material, which for the present we may name black 31, for the wave length which brings it out. Silver on glass mirrors, as I have pointed out will not be suitable. What we need is a metal speculum of long focus, say 8 or 10 meters (26.25 or 32.81 feet). It is my hope that some observatory or amateur is already equipped for the work and will undertake it. If not, I shall have a horizontal telescope constructed for the purpose. The preparation of suitable silver films which are structureless by transmitted light requires special precautions. It is possible that a thin sheet of the new Uviol glass would do in the place of the quartz.

WHAT WE KNOW ABOUT THE EARTH.*

MANY PUZZLING QUESTIONS ANSWERED BY SCIENCE.

BY E. WEICHERT.[1]

The explorer of nature is naturally inclined to direct his search to the earth itself, on whose surface we live. He asks what secrets may lie hidden in the depths beneath our feet. My purpose is to set forth some of the answers which science is now able to give to that question.

The simplest method, of course, would be for the explorer himself to penetrate into the earth by the way pointed out by the miner. But this hope quickly vanishes as we survey the means at our disposal and the results thus far achieved. Mining operations extend to a depth of about 1 kilometer (3,280 feet); the deepest shaft ever bored reached a depth of about 2 kilometers (6,560 feet), and the center of the earth is 6,370 kilometer (3,958 miles) beneath us.

What are 2 kilometers compared to that? Imagine the earth represented by a ball 13 meters (42 feet) in diameter; then a shaft 2 kilometers (6,560 feet) deep would be represented by a needle prick 2 millimeters (about one-twelfth inch) deep! And yet the sinking of such a shaft is a work of exceeding difficulty; with every meter the difficulties increase at an accelerated rate, soon outstripping all human power.

Thus in our search into the interior of the earth, apart from a very thin superficial layer, we must depend entirely on the resources of science.

Immediately beneath us we find masses of rock; that we know for certain. But what is there farther down? Does the rock continue throughout all the depths, or shall we come to metals? Rocks are comparatively light, the metals that might be expected are comparatively heavy. Hence if the density of the earth's material is known, we shall have a datum point from which we may judge. To this, science has in fact been able to supply an answer within certain limits.

The starting point of the demonstration is the law of universal gravitation. You will remember that the English scientist Newton was the first to recognize the influence of that force in the making of the world. Gravitation holds the earth together, holds us fast to its surface, determines what is "up" and "down." As the child's strength increases it must learn to stand erect in opposition to gravitation; with advancing years the old man feels more and more its downpulling force. It compels the moon to describe its orbit around the earth; it determines the movement of the planets around the sun. Summing up his observations, Newton was led to the conclusion that all matter without exception is mutually attractive, no matter what may be the size of its particles or the distance between them. According to his law, the smaller the mass, and the greater the distance, the less is the attraction; but it never becomes zero. We are thus driven to the conclusion that the various objects which we encounter on the surface of the earth also attract each other. Is this true? In daily life, indeed, the effect is not perceptible. Your thoughts may at this moment be turning to the electrical and magnetic phenomena in which attraction is distinctly observed; but these do not belong here; they are the effects of forces quite different in their nature from gravitation. In point of fact, by means of delicate instruments it has been possible to demonstrate and measure the mutual attraction of the objects that surround us. If a body, say a metal globe or any other object, be so suspended as to be protected against disturbance, while the thread that holds it offers a minimum of resistance, and if thereupon another body, say a lead weight, be made to approach it, the suspended body will be seen to move toward the approaching body, and thus fall toward it, even though slowly, just as the apple, detached from the tree, falls to the earth. As the approaching body is small in comparison with the earth, it is to be expected that some minutes will elapse before the suspended body shows a movement of even a few millimeters, while the apple falling to the earth passes through a distance of 5 meters in the very first second. The observation of the mutual attraction of surrounding bodies is a task to which physicists have devoted much attention and on which they are still constantly engaged. Numerous observers have spent on this problem all their labor and ingenuity for years, and have used all the available resources of micro-mechanics. In this way we have at last arrived at a very accurate estimate of universal gravitation and are able to state with precision the force of attraction exerted on each other by two bodies measured in grammes or kilogrammes. Now these are the observations which may be employed in estimating the mass of the earth. We know directly the force with which the earth attracts bodies on its surface, we also know the size of the earth and therefore the distance between its various parts and the bodies on its surface; and thus the laboratory observations on the mutual attraction of bodies enable us to calculate the total mass of the earth. We find that the total mass is five and a half times greater than it would be if the entire space occupied by the earth were filled with water; in other words: The various kinds of substances contained in the earth are on an average five and a half times denser than water. This figure, 5½, is the culmination of all the observations on gravitation of which I speak. But in this number the physicist also perceives the outcome of a sum total of human labor, by which one of the forces of nature dominating the world has been brought nearer to human perception.

The rocks on the earth's surface are only 2½ to 3½ times heavier than water; hence, since the earth is on an average 5½ times heavier than water, it follows that at a certain depth the density must be greater than 5½. It has been suggested that this greater density may simply be an effect of the pressure exerted by the overlying layers of the earth on the underlying. I have never been able to subscribe to that view, since everything that we know concerning the constitution of matter, and its construction out of the highly resistant atoms, indicates, it seems to me, that a notable compression by the pressure of the earth is not to be expected. Thus it seems to me that the greater density in the deeper depths of the earth's interior can only be explained by assuming that heavier substances, especially metals, predominate there. At any rate, you see that we are here in a state of uncertainty. We are compelled to ask, Are there not other means by which the distribution of mass in the body of the globe may be inferred? In point of fact, they may be found. First of all, there are the observations on the shape of the earth.

You know that the earth—assuming its surface to be represented by the surface of the sea, which we conceive as extending also through the continents—is not an exact sphere, but has been flattened at the poles, owing to the centrifugal force of its rotation. This flattening is of the greatest importance for general geophysics and for all estimates concerning the mutual position of points on the earth's surface. It must be taken into account in all land measurements, in all surveys intended to ascertain the geographic distribution of lands. Such geodetic observations form also the basis of the calculations by which we ascertain the size of the earth. The magnitude of the flattening also manifests itself in the distribution of gravitation on the earth's surface. That this may be the case you will readily understand, if you consider that it is gravitation that determines the shape of the surface of the sea. It has been found that gravitation becomes greater the farther we remove from the equator and approach the poles. One kilogramme at the pole exerts the same force as 1 kilogramme 5 grammes at the equator. A pendulum clock set correctly at the equator would gain 3½ minutes every day at the pole, by reason of increased gravitation, though the length of the pendulum remains the same. The observation of these variations in gravitation is also one of the methods by which we may infer the flattening of the earth. It would even seem as if this method were at present the best. This is all the more the case because an enormous number of observations have been made in the study of variations of gravitation on the globe, for the purpose of determining the flattening and for other geophysical purposes, some of which I will mention later on. On mountains, in valleys, in plains, in

* Translated in the Smithsonian Institution Report from Deutsche Rundschau, Band CXXXII.

[1] Address delivered for the benefit of the Göttingen Ladies Union.

the interior of continents, on coasts, on islands, on the open sea, measurements of gravitation have been made. The Geophysical Institute of Hainberg possesses a special treasure in an apparatus for the measurement of gravitation, which some years ago was carried by the German South Polar Expedition on the ship named after our great mathematician, astronomer, and geophysicist, Gauss, of Göttingen, in order to make gravitation measurements in the South Polar Sea, so rarely visited by human beings. As the shape of the earth is influenced by the distribution of gravitation, it also shows itself in the effect exerted by the earth on the moon. By reason of the flattening of the earth, the moon revolves somewhat differently from what would be the case if the earth were a perfect sphere. Here is a third way of determining the flattening of the earth. It is practicable, too, for the movements of the moon must be determined with extreme care, on the one hand for scientific reasons, and on the other because the movement of the moon in the sky supplies an important means for determining geographic position, which is of importance, especially for the navigator. Now the final result of thousands of observations and of the extensive mathematical investigations to which I alluded culminates in the statement that the flattening of the earth amounts to about one two-hundred-and-ninety-eighth—that is to say, that the radius of the earth at the pole is about one two-hundred-and-ninety-eighth shorter than the radius at the equator. You will notice that, as in the case of the measurement of gravitation, the final result of an immense amount of labor is a simple numerical figure; but you will understand that to the investigator this one figure recalls the struggles, the toil, the success of a whole science.

I will mention that the figure one two-hundred-and-ninety-eighth is not yet quite accurately determined; it is possible that the value one two-hundred-and-ninety-seventh or even one differing still more may prove to be the true value.

Now, what significance has the flattening for our speculations on the interior of the earth? For an answer we must apply to the mathematical theory of gravitation. It tells us, first of all, that the flattening would have to be one two-hundred-and-thirtieth if the masses in the earth were uniformly distributed, and one five-hundred-and-seventy-eighth if the main mass were located at the center. As the real flattening is one two-hundred-and-ninety-eighth, or very nearly that, it follows that the distribution of the mass in the interior of the earth lies between the two extremes; that is to say, the density increases toward the center, but at such a rate that a notable part of the mass is present in the outer layers. This, in fact, is the result at which we have already arrived. A further conclusion to be deduced from the figure one two-hundred-and ninety-eighth is a certain statement concerning distribution, which can be formulated only in its full extent by means of mathematics. The situation becomes much more favorable, if I now make use of the suggestion, already referred to as a very natural one, that the earth consists of a metal core enveloped in a mantle of rock. As we know the thickness of the rocky mantle to a certain extent from direct observation, we are enabled, on the basis of the figure one two-hundred-and-ninety-eighth, for the flattening, to calculate the size of the metal core and its density. It is found that the rocky mantle on which we live must be 1,300 to 1,600 kilometers thick (800 to 1,000 miles), and that therefore the metallic core, so far as its diameter is concerned, occupies about four-fifths of the globe. It also appears that the density of the metal core must be a little more than eight times as great as that of water. The density of iron under the pressure conditions known to us at the earth's surface is a little less than eight. Thus we see that we obtain for the density of the metal core of the earth a figure corresponding to the density of iron when somewhat compressed or somewhat alloyed with heavier metals (for example nickel). We are thus led to the conjecture that the metal core consists in the main of iron. In support of this conjecture we are able to bring forward quite an array of additional arguments. In connection with volcanic eruptions, rocks rich in iron are often ejected from the depths of the earth. The meteorites which drop on the earth from planetary space consist partly of rock and partly of metal, iron being by far their predominant constituent. Analysis of the sun's light by means of the spectrum shows that iron vapors have a vast share in the composition of the sun. It thus appears that iron is very strongly represented in the structure of our solar system, and in particular that our earth is simply an iron ball coated with rock. It simply represents on a larger scale a meteorite which consists of a mixture of rock and iron.

Interesting as these conclusions are, we must not forget that they rest as yet on a very weak foundation. They would vanish at once, for example, if the increase of density toward the interior of the earth were merely an effect of pressure and not of difference in material. It is exceedingly fortunate, therefore, that our conclusions receive new and very strong support from another and entirely different direction, that of earthquake investigation. But before I proceed to explain this, I must refer to two other phenomena of nature, whose data may be utilized in drawing conclusions concerning the condition of the interior of the earth.

I refer to the question of the plasticity of the earth under the influence of deforming forces. Aside from the phenomenon of earthquakes, there are two natural processes that bear on the question—(1) tides, (2) polar oscillations.

The tide, that "breathing of the sea," is to you a familiar phenomenon in its main features. Many of you have doubtless been eye witnesses of it on the shores of the North Sea. The causes of the tides are easily understood; they are to be sought in the attraction of sun and moon. Each of these heavenly bodies attracts the water of the sea more strongly on the side of the earth nearer to it than it does the earth's body as a whole, while on the opposite side of the earth it attracts the water of the sea more feebly than it does the body of the earth, which in this case is nearer to the attracting body. The stronger attraction on the near side, as may readily be seen, produces an upheaving of the water—that is to say, a flood tide; but there is also a flood tide on the off side of the earth, because, since the water there is more feebly attracted than the earth's body as a whole, it assumes, in the course of the earth's movement in space, a position relatively more distant from the attracting body than the earth, which means nothing else than that it rises in the form of a flood tide, relatively to the earth. Thus both the sun and the moon are each accompanied by two flood tides, one on the near side, the other on the off side of the earth; and in view of the revolution of the earth and the relative movements of the heavenly bodies, the result is that to the observer on the earth's surface sun and moon are each followed in their course around the earth by two flood tides. The moon is so much closer to the earth than the sun that despite its smaller mass the tides caused by it are more than twice as large as those caused by the sun. As a consequence, the sun tides do not present themselves as separate from the moon tides, but merely as modifications of them. At new moon and full moon the sun's tide re-enforces the moon's tide, and we have the so-called "spring tides." At half moon the sun's tide is opposed to the moon tide, and then we have the "neap tides." At any rate, to the observer the tides seem always to follow the moon in its course through the heavens. Because of the daily revolutions of the earth around its axis and the moon's own motion about twenty-five hours pass before it has accomplished apparently one revolution around the earth, and thus, inasmuch as two flood tides are moving around the earth, the tide phenomena recur at intervals of about twelve and one-half hours.

I have tried to set forth to you the fundamental facts of the tide phenomenon, but I must add that in reality the process is exceedingly complicated. On the one hand, astronomic factors enter into the problem, for example, the fact that both the sun and the moon are now farther north and again farther south; on the other hand, the irregularities in the distribution of water and land on the earth lead to extensive modifications in the course of the tides which are difficult to estimate. How strong these influences are you may gather from the fact that the tides on the shores of the North Sea come from the Indian Ocean. South of America, Australia, and Africa there is a broad belt of open water; there the tide waves develop freely. Starting from the Pacific they run through the Indian Ocean, and as they enter thence into the Atlantic Ocean south of Africa, a part of each tide wave is deflected northward into the Atlantic Ocean. In the course of a little more than twelve hours these partial waves reach England and then pass around it on the south and north into the North Sea. The velocity becomes slower and slower with decreasing depth. After issuing from the Indian Ocean it takes the tide about two days to reach our German coasts.

Now, what does the tide teach us regarding the condition of the globe? If the earth were entirely plastic—that is to say, if the interior were in the main in the liquid or even the gaseous condition, as has been assumed from time to time by the imagination of some scientists—there could be no ebb or flood. The earth's body itself would in that case be deformed under the varying attraction of the sun and moon, and the result would be that a relative movement of the sea such as is indicated by the rise and fall of the tide could not take place. Hence, the existence of tides proves that the earth acts in the main as a solid body.

Thus there can be no doubt that the earth possesses a certain power of resistance to changes of form. But what is the extent of this power? Combining observation and calculation, we can draw an inference on this point also. The ordinary half-daily tide, indeed, can not be used for that purpose, because, in regard to this, it would be too difficult to form a correct estimate of the influence of the irregularities in the distribution of land and water. But the half-monthly tide connected with the movement of the moon from north to south and back, in its revolution around the earth, may be utilized, for in this case, owing to the slowness of the process, the sea has time to follow the varying forces of attraction without disturbing current phenomena. This half-monthly tide, indeed, is very small, but in view of the extreme precision with which, in the interest of navigation, the changes of sea level are observed and used for calculation, it is possible to disentangle it from the apparent chaos of oscillations. If thereupon we compare the size of the real flood with that which might be expected according to mathematical theory, with that which according to calculation should result from the moon's attraction, we find that the globe is certainly at least as rigid (riege) as steel. Let me explain the word "riege," which is somewhat unusual. You know that even steel is flexible; every knife blade, every steel pen proves it. The less yielding a material is in this sense, under the influence of the same force, the more rigid (riege) it is. Steel is one of the most rigid bodies that we know. Now, the behavior of the earth as regards the tides proves that in rigidity it is at least equal to steel. This remarkable result is confirmed and defined with greater precision by an examination of what are called "polar oscillations."

As you are aware, the "geographic latitude" of a place is measured by degrees of an angle. By this we mean the angle which the plumb line forms at the place in question with the axis of revolution of the earth. This latitude is of fundamental importance in all astronomic measurements, and hence it receives the most careful attention in all observatories. Now it was noticed that the observations did not always give exactly the same latitude. At first it was suspected that this arose from local disturbances of observations, against which the observer has to struggle constantly in all scientific researches. But when the thousands and tens of thousands of observations were systematically tested, it became apparent that the cause was to be sought not in local but in cosmic influences. It appeared probable, and it was afterwards demonstrated by observatories specially erected for the purpose, that the cause is to be sought in continual displacements of the axis of revolution of the earth. In other words, the earth does not turn steadily on the same axis, but changes its axis of revolution constantly within certain limits. Imagine that you are stationed at the place where the imaginary axis emerges from the globe; that is to say, at the "poles" of the earth in the astronomic sense, and you will have to conceive these "centers of revolution" as being located not at an invariable point of the earth's surface, but as shifting their positions. According to the observations thus far made, they migrate around certain definite mean positions, from which they depart at times as much as 10 meters.

What mean these migrations of the poles of revolution? That they can take place at all is not surprising to the physicist, for the earth is essentially a spinning top, and such "pole oscillations," that is to say, such displacements of the axis of revolution, may be observed in every top. Mathematical theory teaches that they must occur whenever the axis of revolution does not coincide accurately with the "axis of figure." It is safe to assume that the rotation of the earth does not take place precisely around the axis of figure, nor is this surprising, for we do not know the early history of the earth which has brought it to its present condition. But the moment we examine the pole oscillations on the basis of existing observations more accurately, we find several remarkable facts. Theory teaches the following: If the earth were perfectly rigid, that is to say, if it were not yielding in the slightest degree, and if no disturbances intervened, the axis of revolution would have to move incessantly and with the same velocity around the axis of figure, so that the astronomical poles of the earth would constantly describe the same circles around the mean position. Astronomy is able to indicate in what time a revolution would be completed, namely, in three hundred and five days. But when we consult the observations we find a totally different course of the pole oscillations. There is indeed a circular movement of the poles in the true sense, but it takes place not in three hundred and five days, but in four hundred and twenty-five days. Moreover, the curves described change their width in an apparently irregular manner from revolution to revolution. These latter irregularities indicate that disturbing causes are constantly at work which continually displace the axis of revolution. It has been found that even the meteorologic processes in the atmosphere suffice to explain these displacements. Some geophysicists suggest that earthquakes may co-operate. Be this as it may, it is evident that the irregularities present no difficulty to the explanation, and thus we need not trouble ourselves about them. But what shall we say to the fact that the circular path of the poles is traversed not in three hundred and five, but in four hundred and twenty-five days? Here we have arrived at the point which invests the phenomenon of pole oscillations with great significance

for the question of the condition of the globe. In fact, from the difference between the observed time of revolution and the time ascertained by calculation under the assumption of a perfectly rigid globe, it may be inferred that the earth is not absolutely rigid but plastic. Part of this plasticity is to be accounted for by the movable, liquid body of the sea; but it can be shown that this accounts for only about one-fourth of the difference between three hundred and five and four hundred and twenty-five days. Hence the earth beneath our feet, which to our senses seems absolutely rigid, must to a certain degree be yielding. It is possible to calculate this degree of yielding, and we find that it is about half as great as if the globe possessed the rigidity of steel. In other words, the earth opposes to the deforming forces about twice the resistance that steel manifests under the conditions under which we observe it in our daily life. You see that the phenomenon of the pole oscillations carries us much further in our inquiry into the condition of the globe than does the phenomenon of the tides. From the observation of the tides we were merely able to infer that the earth is at least as rigid as steel. We had no ground for assuming that it was not absolutely rigid. The pole oscillations, on the other hand, demonstrate that the earth is not absolutely, but only relatively, rigid, and they indicate the degree of rigidity.

Far greater yet is the degree of precision which our conclusions many attain along another line of research, to wit, that of earthquakes.

(To be continued.)

SCIENCE NOTES.

In a recent issue of the Physical Review Mr. J. A. Veazey describes an investigation of the magnetization curves for a sample of iron wire one mil in diameter, the experiments being made with the object of obtaining an idea of the relative magnitude of the molecules or groups of molecules constituting the elementary magnets of which a large magnet is thought to consist. If the magnetization curves showed changes indicative of sudden alteration of magnetic flux in the wire the inference would be that the groups were of the order of one mil in magnitude. The apparatus used was a modification of that employed by Ewing. The curves obtained were perfectly smooth, and the conclusion reached is that the elementary magnets, of whatever kind they may be, are less than one mil in order of magnitude.

Mr. H. E. Ives points out in the Electrical World that most of the devices and charts employed by observers in the past for the determination of visual acuity are open to objection on some ground. The ideal conditions to be met by such a device are: (1) That the detail inspected should be continuously variable in size; and (2) that the flux of light entering the eye, the distance of the object, and the observer's visual accommodation should remain constant. Mr. Ives describes a method of securing the required conditions which involves the superposition, one over the other, of two finely ruled gratings. As the inclination of the lines on the gratings is altered, the observer sees alternate dark and bright bands, the width of which is determined by their relative position. In using the apparatus the angle of inclination is adjusted until the bands are just indistinguishable; the corresponding angle is then noted and regarded as an index of visual acuity. Mr. Ives presents some microphotographs explaining the exact action of the crossed gratings.

Some interesting studies have been made on the polarization of skylight by H. H. Kimball, of the Mount Weather Observatory. His observations were confined to cloudless days. The sources of illumination of the sky are considered to be (*a*) the scattering of light by particles in the atmosphere whose diameters are small as compared with the wavelength of light, (*b*) the scattering by relatively large particles, (*c*) the reflection of light from the surface of the earth. At the point of polarization, i. e., the point in a plane through the sun and the zenith at zenith distance equal to the complement of the sun's zenith distance, the component depending on (*a*) is polarized, while the components depending on (*b*) and (*c*) are, in effect, unpolarized. The observations, made with a Pickering polarimeter, determined the ratio of (*a*) at the point of max. polarization to the total sky illumination. (1) When the ground is covered with snow there is a marked decrease in the percentage of polarization, due to increased reflection from the surface of the earth. (2) There is a diurnal variation in the percentage of polarization, the minimum occurring at noon, with a gradual increase as the sun approaches the horizon, and a marked increase during the first few minutes of twilight following sunset, which may be attributed to relatively less reflection from the ground than from the particles in the atmosphere as the zenith distance of the sun increases. (3) The last part of the paper attempts to find a connection between the percentage of polarization and the general absorption of the atmosphere as determined from simultaneous pyrheliometer observations made at different levels. The percentage of polarization decreases as the general absorption increases, but not according to a simple law.

ELECTRICAL NOTES.

It is proposed in a patent issued to Mr. S. R. Bergman, to improve the starting torque of a squirrel-edge induction motor by providing two end rings in parallel, one of low and the other of relatively high resistance. A laminated iron ring mounted on the rotor shaft is so arranged that it can be utilized to or from the low-resistance end ring, and in this way vary the reactance of this circuit. When starting, the reactance of the low-resistance circuit is a maximum, and more current will be carried by the high-resistance ring than by the low-resistance ring, thus reducing the total current and increasing the torque.

It is announced by the Prussian State Railways Administration that plans are being prepared for the electrification of the main lines between Madgeburg, Zerbst, Leipsic and Halle, especially the Dessau-Bitterfeld section. According to a contemporary, a large central power house is to be erected at the village of Muldenstein, near Bitterfeld, the selection of this locality being due to the large quantities of cheap coal available in the district. Alternating-current electric locomotives are to be used, employing current at 10,000 volts. Dessau and Bitterfeld will be the first substations.

A paper by W. P. Steinthal, accepted for publication in the Journal of the Institution of Electrical Engineers, considers the arrangement of experimental electrical circuits for laboratories. The author points out that a battery of accumulators is essential, as it is the only means of providing a steady pressure and also a number of different pressures. The battery may consist of from 35 to 55 cells, and, as the cells will be unevenly discharged, the author suggests the use of two small charging dynamos for half the total pressure each, both coupled to the same motor. For supplying alternating current, a motor generator with a single-phase armature, divided into four sections, capable of being connected in series or parellel, is recommended. For distribution, bar conductors are advocated as being cheapest and most easily adapted to new arrangements. Various ways of arranging the circuits are described, and plug boards for supplying any circuit at any required pressure alternating-current or direct-current, are illustrated. Finally, some recent laboratory equipments carried out on these principles are described with diagrams and connections.

At a meeting held recently at Helsingborg, in Sweden, Mr. Gösta Forssel, engineer, of the Höganœs-Billesholm iron works, exhibited some samples of carbon-electrodes for electrical furnaces, which had been made at the Höganœs works since 1907. One of the electrodes exhibited measured 80 inches in length and 13 inches square. These electrodes have been adopted by a Norwegian works where they are used in bundles, each bundle consisting of twelve electrodes. The manufacturers, however, intend within a short time to increase the dimensions, with which object in view they have ordered an electrode press, which, probably, as regards size, will beat all existing records. The material from which the electrodes are manufactured is composed of a mixture of graphite, anthracite, and petroleum coke with tar. The whole of the raw material, apart from the tar, is imported from abroad. At the same time were shown samples of iron sponge, which forms a raw material for the manufacture of open-hearth steel, and which is treated in special furnaces at the Höganœs works by means of inferior Swedish coal.

ENGINEERING NOTES.

It is probable that the huge excavation for the new station yard of the New York Central Railway will ultimately be covered with buildings. Contracts have already been signed for the construction of two large buildings facing Lexington Avenue, and to be supported on the heavy steel columns of the underground station. The buildings, which will be known as the Merchants' and Manufacturers' Exchange, will contain more than thirty acres of floor space.

According to a contemporary, a cement which is effective for cementing rubber to iron, and which is specially valuable for fastening rubber bands to band-saw wheels, is made as follows: Powdered shellac, one part; strong water of ammonia, ten parts. Put the shellac in the ammonia water, and set it away in a tightly closed jar for three or four weeks. In that time the mixture will become a perfectly liquid transparent mass, and is then ready for use. When applied it forms a firm bond.

With a view to tracing the flight of shells during night firing, the military authorities have tested a new invention with 12-pounder guns from Fort Albert, Isle of Wight. It consists of a metal cylinder, which is screwed to the base of the shell, and contains some powerful illuminant. This is fired by the explosion, and continues to burn brightly during the flight of the missile. The invention is said to have proved very satisfactory, and is likely to be of great use in correcting ranges.

According to the Railway and Engineering Review the passenger train No. 4 of the San Pedro, Los Angeles and Salt Lake Railway holds the indisputable record for slow-speed travel. On December 31st it started for Salt Lake City, listed as a "fast train." It was caught by the storm of January 1st a short distance east of Caliente, Nev., which washed out the track before and behind it. On May 17th it arrived at Salt Lake City, 137 days out from Los Angeles. The passengers were transferred by wagons on January 10th. A Pullman porter stayed by his car for a month; and, subsequently, a railway watchman was the only guard.

According to a report by M. Colmet Daade, the engineer-in-chief to the commission appointed to consider the question of flood prevention in Paris, the main drainage is inadequate for safeguarding the city in the event of an unusually wet summer. Owing to the numerous bends of the river within the metropolitan area, the risk of flooding Paris is even greater than that of London as it was before the important extensions which have been made to the drainage system during recent years. Consequently, it is desirable that steps should be taken without unnecessary delay. At the present time recent rainstorms have had the effect of raising the level of the river by several inches—a development which has probably influenced the Prefect of the Seine Department to ask the Municipal Council for a sum of 200,000f. for the execution of flood prevention works.

The work of elevating the tracks of the numerous steam railway companies traversing the city of Chicago, begun a number of years ago, is still proceeding in outlying districts. Street railway tracks crossing any section of the proposed elevated road bed must be changed in the subways at the expense of the owners. Likewise all private-owned overhead wires or cables crossing the section of track to be elevated must be placed in some temporarily safe position during the early stages of construction work on notice from the railway company. Later the crossings must be made in underground conduits or else the wires must be attached to the underside of bridges in the street subways. The work of making this change is done at the sole expense of the owners of the wires, except in the case of overhead wires belonging to the city, which are changed at the expense of the railway company.

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